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VOLVO ENVIRONMENT PRIZE

GOVERNMENT-INDUSTRY-CIVIL SOCIETY PARTNERSHIPS IN INTEGRATED GENE MANAGEMENT*

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At the outset, I would like to express my deep sense of gratitude to the Volvo Environment Prize Foundation for choosing me for this prestigious award. I accept it with humility on behalf of my numerous colleagues, students as well as the rural and tribal women and men with whom I work. Through the institution of this Prize, the founders of the Volvo Environment Prize Foundation have shown their deep commitment to fostering a better care of the Earth's ecosystems and their management, I wish to pay my tribute to all those connected with the management of this Prize for their dedication to the cause of a better today and tomorrow for all members of the human family.

We all live on this planet as guests of the green plants which help to convert sunlight into various agricultural commodities and of the farm families who toil in sun and rain to cultivate them. I wish to dedicate this lecture to the millions of rural and tribal families who not only conserve the world's rich bioresources but also serve as the backbone of the global food and health security systems.

On the eve of the UN Conference on Environment and Development (UNCED) held at Rio de Janeiro in June 1992, the Union of Concerned Scientists published an open letter titled, "World Scientists' Warning to Humanity", which stated that "human beings and the natural

world are on a collision course". The letter stated further, "if not checked, many of our current practices put at serious risk the future that we wish for human society and the plant and animal kingdoms, and may so alter the living world that it will be unable to sustain life in the manner that we know". This warning was signed by over 1600 scientists from leading scientific academies in 70 countries. The list included 104 Nobel Laureates.

Colborn, Dumanaski and Myers (1996) in their book "Our Stolen Future" and James Morgan (1999) in his book "The Last Generation" also provide a picture of the grim future that awaits the generations yet to be born, if we lose further time in restoring harmony between humankind and nature.

A Chinese proverb warns, "if you do not change direction, you will end up where you are headed". Since we do not want to reach where we are presently headed, what change of course should we bring about?

I wish to take biodiversity, one of the key components of our basic life support systems, as an example to illustrate what changes are needed in the management of our biological resources. It is now widely realized that the genes, species, ecosystems and traditional knowledge and wisdom that are being lost at an increasingly accelerated

*Lecture delivered by Dr M. S. Swaminathan on Conferment of "Volvo Environment Prize" on him, New York (USA): October 26, 1999

pace limit our options for adapting to local and global change, including potential changes in climate and sea level. The Global Biodiversity Assessment published in 1995 by the United Nations Environment Programme (Cambridge University Press) estimates that about 13 to 14 million species may exist on our planet. Of this, less than 2 million species have so far been scientifically described. Invertebrates and microorganisms is still poor. Also, biosystematics as a scientific discipline is tending to attract very few scholars among the younger generation.

Another important paradigm shift witnessed in recent decades in the area of management of natural resources is a change in the concept of "common heritage". In the past atmosphere, oceans and biodiversity used to be referred to as the common heritage of humankind. However, recent global conventions have led to an alteration in this concept in legal terms. Biodiversity is now the sovereign property of the nation in whose political frontiers it occurs. Under the UN Convention on the Law of the Sea, nations with coastal areas have access to a 200 mile Exclusive Economic Zone (EEZ). For example, the ocean surface available to India under the EEZ provision is equal to two thirds of the land surface available to the country. The Climate Convention and the Kyoto protocol provide for both common and differentiated responsibilities to countries. Thus, the global commons can be managed in a sustainable and equitable manner only through committed individual and collective action among nations.

BIODIVERSITY AND HUMAN SECURITY

While we have some knowledge of variability at the ecosystem and species levels, our knowledge of intra-specific variability is poor, except in the case of plants of importance to human food and health security. The Global Biodiversity Assessment warns, "unless actions are taken to protect biodiversity, we will lose forever the opportunity

of reaping its full potential benefit to humankind". What kind of action will help us to ensure not only the conservation of biodiversity, but also its sustainable use? I would like to discuss this issue with reference to the following three major threats to biodiversity in general, and agrobiodiversity in particular.

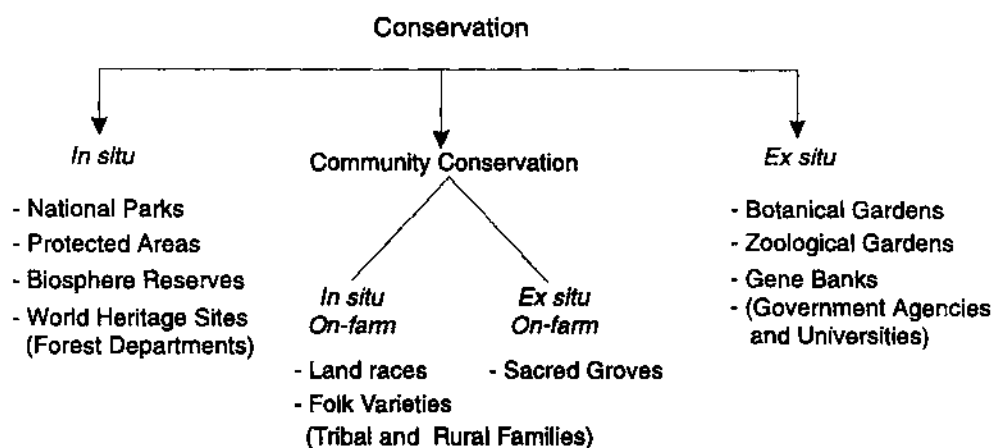
- Habitat destruction
- Alien species invasion
- Genetic homogeneity in farming systems

A. Habitat Destruction

UNEP's Global Environment Outlook - 2000 states, "Reduced or degraded habitats threaten biodiversity at gene, species and ecosystems level, hampering the provision of key products and services. The widespread introduction of exotic species is a further major cause of biodiversity loss. Most of the threatened species are land-based, with more than half occurring in forests. Freshwater and marine habitats, especially coral reefs, are also very vulnerable". How do we arrest this trend and prevent further genetic erosion? I would like to summarize briefly the approach adopted in India as well as at our Research Centre in Chennai (Madras) to foster an Integrated Gene Management strategy in the country. We use the term management in the context of natural resources to include conservation, sustainable use and equitable sharing of benefits. It is only such a concept of management that can result in the conservation as well as enhancement of natural resources.

The Integrated Gene Management system includes *in situ*, *ex situ* and community conservation methods. The traditional *in situ* conservation measures comprising a national grid of National Parks and protected areas are generally under the control of Government environment, forest and wildlife departments. The exclusive control of such areas by Government departments has often led to conflicts between forest dwellers

Integrated Gene Management



and forest dependent communities, and forest officials. The non-involvement of local communities in the past in the sustainable management of forests has resulted in a severe depletion of the forest resources in India. It has become clear that sole government control alone will not be able to protect prime forests or regenerate degraded forests.

Participatory Forest Management (PFM)

The Participatory Forest Management (PFM) procedure initiated first at Arabari in the state of West Bengal in India in 1972, largely at the initiative of a young Forest Officer, Mr. Ajit Kumar Banerjee, and later extended to the other States in the country, became a significant turning point in the history of forest management in India as well as other Asian countries (see Samar Singh *et al.*, 1997 and Mark Poffenberger *et al.*, 1997). The essential feature of this system is that the State and community become partners in the management of the forest resource. The State continues to own the resource but the benefits are shared. Access to non-timber forest products becomes an important avenue of sustainable livelihoods to the forest-dependent communities. Thus, the community develops an economic stake in the preservation of forests, leading to conservation and sustainable use becoming mutually reinforcing

components of a Forest Management Policy. The experience gained in India during the last 25 years shows that the process of natural forest degradation can be reversed through PFM and that forests can provide to the local community non-wood forest products on a continuous or seasonal basis, if there is a more widespread understanding of their regenerating capacity. Since forests are the home for a large proportion of naturally occurring biodiversity, saving forests results in saving genes.

Community Gene Management

Both *in situ* on-farm conservation of intra-specific variability, particularly in plants of food and medicinal value and *ex situ* on-farm conservation through sacred groves have been part of the cultural traditions of rural and tribal families in India. In the old Testament also, there are several references to sacred groves. Among the important trees usually preserved in Indian Sacred Groves are : *Ficus religiosa*, *Saraca asoca*, *Shorea robusta*, *Alstonia scholaris* and many other species of ecological, economic and spiritual value. Gadgil and Vartak (1975) defined sacred groves as tracts of forest that have been completely immune from human interference on the basis of religious beliefs. Unfortunately, several of these traditions are now tending to wither away. It is only by giving

explicit recognition to the pivotal role of community conservation in strengthening ecological, food and health security systems that we can succeed in the revitalization of these traditions. In national integrated gene management systems, *in-situ*, *ex-situ* and community conservation methods should receive adequate and concurrent attention. A recognition and reward system, based on FAO's concept of Farmers' Rights and CBD's provisions for ethics and equity in benefit sharing, should become an integral part of national legislation in the fields of biodiversity conservation and plant variety protection.

Biosphere Management

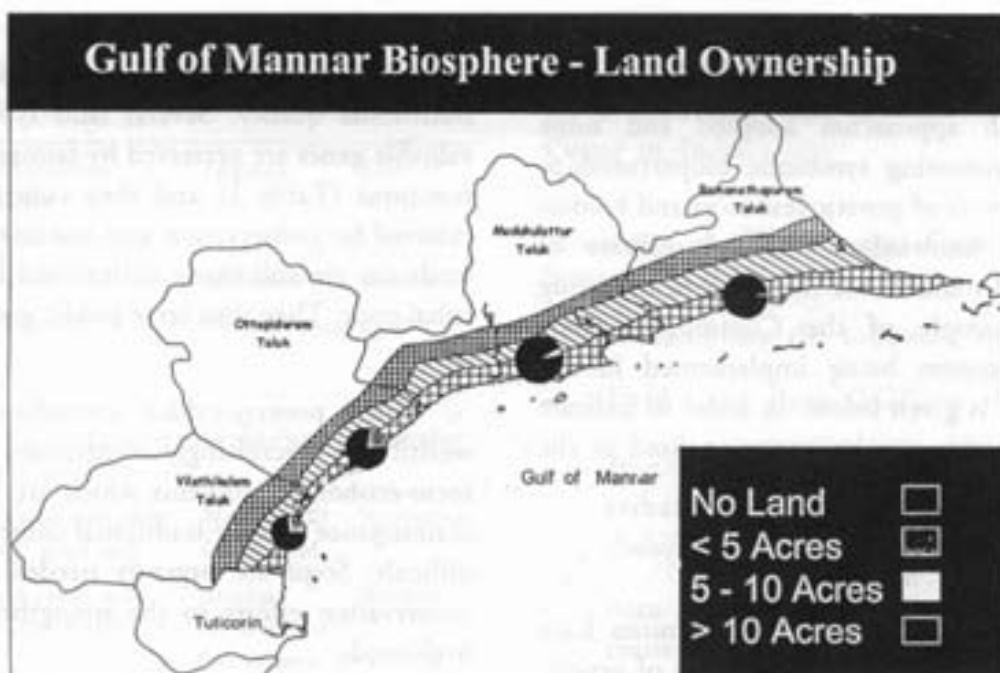
Methods of fostering the sustainable management of Biosphere Reserves were discussed at a conference convened by UNESCO in 1995 at Seville in Spain. The Seville vision states : "Rather than forming islands in a world increasingly affected by severe human impacts, biosphere reserves can become theaters for reconciling people and nature. They can bring the knowledge of the past to the needs of the future". To convert the above vision into field level reality, we have been working for a shift in the nature of management of Biosphere Reserves in India. A brief description of the approach adopted is given below :

India has currently 85 National Parks covering 3.6 million sq km and 448 wildlife sanctuaries covering about 120,000 sq kms in the major biogeographic zones. The total extent of protected areas includes 5 designated as World Heritage sites, 9 biosphere reserves and 6 Ramsar sites. In 1994, MSSRF conducted a detailed study of the threats to the Gulf of Mannar Biosphere Reserve in Tamil Nadu. The study showed that unless the livelihood security of the families without assets living in that area can be strengthened, unsustainable exploitation of biological resources will continue.

During 1996-98, MSSRF initiated a proposal for bringing the Gulf of Mannar Biosphere Reserve, under a participatory management mode. The project proposal was considered by the GEF Council at its meeting held in May, 1999. The GEG Council approved the proposal and commended it as a model project which deserves to be widely emulated by those preparing similar projects. The Scientific and Technical Advisory Panel (STAP) of GEF endorsed the project for approval with the following remarks. This proposal was submitted by the Government of Tamil Nadu and India to GEF through UNDP for support.

"The project addresses a major challenge, namely the conservation of coastal biodiversity of the highest ecological value in a large area subject to considerable pressure from poor populations upon the sole resources that appear to be at their disposal. To meet this challenge, the project follows the only framework which can succeed, namely to combine the necessary protection of the threatened ecosystem and ecological processes with economic and social benefits which will meet the essential needs of local people, through providing appropriate institutional, financial and managerial arrangements."

The management structure through which people and Nature will get united in the Gulf of Mannar area is through a **Gulf of Mannar Biosphere Trust**. Representatives of fisherman and rural communities as well as all the principal civil society stakeholders will, together with government representatives, form the members of the Trust. The Members of the Trust will hold this unique biological treasure in trust for present and future generations. Considerations of intra- and inter-generational equity will guide the work of the Trust, which will provide a horizontal dimension to the numerous vertically structured activities undertaken in this area both by Central and State governments and private sector



organizations. It is hoped that the Gulf of Mannar Biosphere Trust, whose long term sustainability will be ensured with the help of a Trust Fund, will show the way for promoting a management by partnership system of governance in all the other Biosphere Reserves in the country.

Project Tiger launched in 1972 with support from WWF- International was the first step in institutionalized efforts in the conservation of habitats of endangered animals. An All-India tiger census conducted in 1972 revealed only 1827 tigers in the country as against an estimated 40,000 at the beginning of the 20th century. The 1993 census placed the tiger population at 3750.

One of the tiger reserves is the Similipal biosphere reserve in Orissa. This reserve was set up in June 1994 and covers an area of 2750 sq. km. Of late, threats to this reserve have increased due to both population pressure and commercial greed. Experience with participatory or joint forest management programmes in India has shown that wherever the local communities are fully involved as partners in saving forests, the results have been very encouraging. It is proposed to develop a

similar plan for the Similipal Biosphere Reserve in collaboration with the Government of Orissa. The output of this programme will be the establishment of a *Similipal Biosphere Trust* managed jointly by the major stakeholders.

A major need in such programmes is the strengthening of the livelihoods of the poor families living in the vicinity of the Biosphere Reserve. For this purpose, the Biovillage model of livelihood security will be introduced in the villages around the Reserve. The Biovillage concept of human-centered rural development aims to address concurrently the challenges of natural resources conservation and poverty eradication (Swaminathan, 1999). Market-driven livelihood opportunities will be identified and local families will be assisted in taking to them with the help of institutional credit. The steps involved are:

- Micro-level planning with GIS maps
- Micro-enterprises identified on the basis of market needs
- Micro-credit
- Enlisting the support of industry for contract cultivation by small farmers on the basis of buy-back agreements

GENETIC RESOURCES ENHANCEMENT AND SUSTAINABLE USE

The main approaches adopted and some methods of promoting symbiotic biopartnerships between conservers of genetic resources and holders of traditional knowledge and the utilizers of knowledge and material are indicated in following charts. An example of the Community Gene Management system being implemented in the State of Orissa is given below, in order to indicate how such concepts can be operationalized at the village level.

Community Gene Management

Tribal and rural farming communities have a long tradition of serving as custodians of genetic wealth, particularly landraces often carrying rare

and valuable genes for traits like resistance to biotic and abiotic stresses, adaptability and nutritional quality. Several land types that carry valuable genes are preserved by farmers for religious functions (Table 1) and they constitute valuable material for conservation and sustainable use. Local landraces are still being maintained largely by the tribal poor. They thus serve public good at personal cost.

Such poverty-ridden custodians of genetic wealth are increasingly confronted with severe socio-economic problems which are rendering the maintenance of their traditional conservation ethics difficult. Steps are urgently needed to link their conservation efforts to the strengthening of their livelihoods.

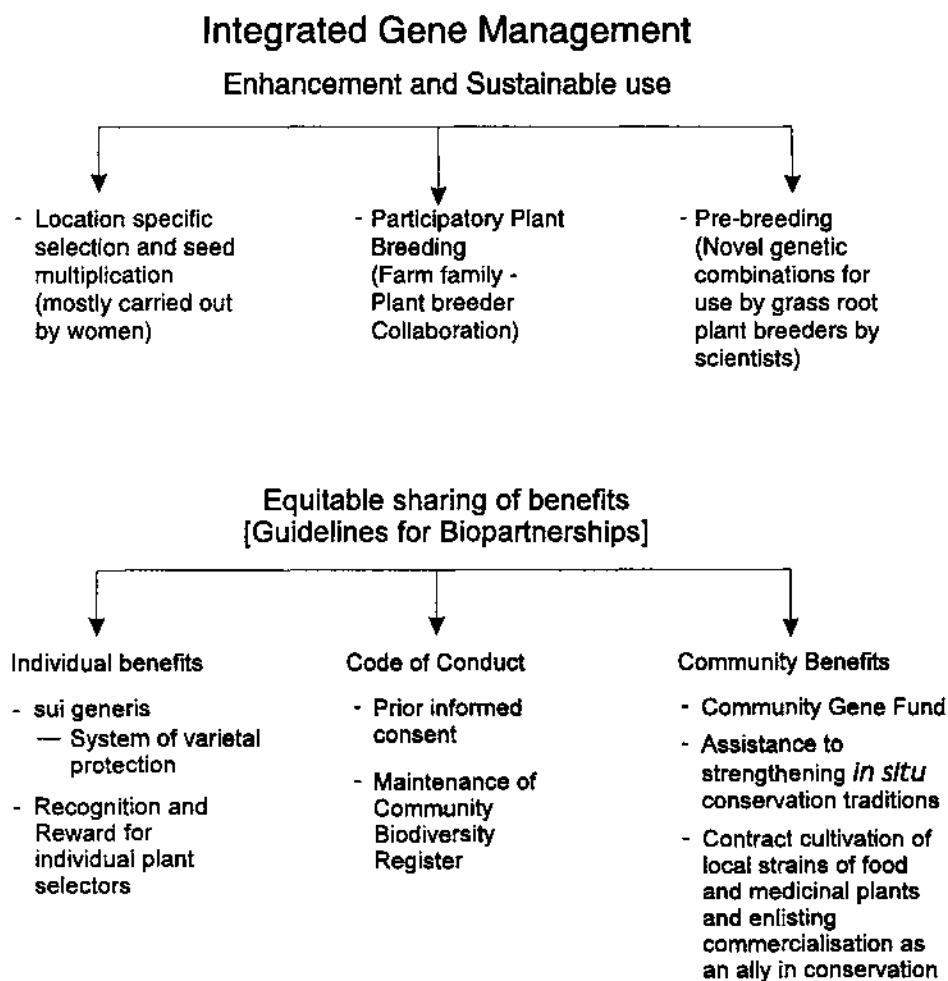


Table 1. Some valuable land types preserved by Orissa tribal farmers for use in their religious functions

Rice Variety	Predominant Quality	Festivals	Time of Maturity (Month)
Kalakrishna	Scented	All festivals	January
Tulsi (<i>Ocimum sanctum</i>)	Scented	<i>Chaitra Parva</i>	April
Haladi-chudi	White slender long grains, good taste	<i>Shakti Puja</i>	December
Machha-kanta	White slender short grains, good taste	<i>Manabasa & Laxmi Puja</i>	November
Mer	Black grains with medicinal properties	Annual ceremony of fore-fathers	November
Deulabhoga	Bold and short grains, reddish tinge on cooking with mild scent preferred during worship at temples	Temple Deities	December

It is now widely recognized that the conservation continuum consists of the following three links :

<i>In situ</i>	<i>In situ</i>	<i>Ex situ</i>
Conservation of habitats	On-farm conservation by rural and tribal and communities	Conservation through Botanical and Zoological gardens and cryogenic gene banks

While the two ends of this conservation chain (namely, *in situ* and *ex situ*) receive support from public funds, *in situ* on-farm conservation by rural and tribal women and men largely remains unrecognized and unrewarded. Yet, this link in the chain is responsible for the conservation of valuable intra-specific variability.

MSSRF's partnership with local communities and government agencies is designed to strengthen this neglected component in the conservation

chain. For this purpose, a Community Gene Management System is being developed, initially in 3 biodiversity-rich districts of the State of Orissa in India.

Structure of Community Gene Management System (CGMS)

CGMS comprises the following three steps.

- Field Gene Bank (FGB) at the village level
- *In-situ* on-farm Conservation by rural and tribal families Participatory Breeding (Selection)
- Area Seed Bank (ASB) at the level of a cluster of villages
- Conservation of representative samples of seeds in seed stores
- Insurance against total loss of seeds during drought years
- Community Gene Bank and Herbarium (CGB)
- Cryogenic preservation
- Evidence for getting tribal families reward and recognition under Plant Variety Protection and Farmers' Right Act (proposed)

Field Gene Banks (FGBs) are basically *in-situ* on-farm centers of conservation. Landraces and location-specific plant genetic resources (PGR), usually identified on a participatory basis with the local families, are conserved in FGBs. The local landraces are periodically grown in their native habitats for seed renewal. They serve as effectively decentralized and highly cost-effective arms of a community gene management system. Those FGBs which are situated at higher elevations are likely to have cooler and conducive climates for storing seeds without loss of viability. No expensive infrastructure is needed to set up FGBs. The FGBs would ensure *in-situ* on-farm

maintenance of landraces and preservation of the cultural and cropping practices under which PGR acquired their distinctive traits. The communities in natural resource areas would be stake-holders in the FGBs. They can then provide active support not only to prevent genetic erosion in those areas, but can add new genetic stocks as and when they discover them. FGBs serve the cause of both conservation and continuous evolution through selection, recombination and mutation.

Several FGBs can be linked to an Area Seed Bank (ASB) taking into account factors like distance, communicability, conservation space and the like. There could be 2 to 3 seed banks in a district. The Area Seed Bank will help to strengthen coping mechanisms for facing the problem of seed scarcity caused by drought-induced crop failures. The ASB would be managed by a committee of the stakeholders. Logically this committee can monitor IPR issues such as prior informed consent and benefit sharing. One or more ASBs will be linked to CGB. The CGB would hold *ex-situ* the seed stocks of landraces etc, along with herbarium sheets and other information needed to get the primary conservers reward and recognition under the proposed Indian Act for Plant Variety Protection and Farmers' Rights. The CGB could deposit duplicate sets of accessions in the National Gene Bank (NGB) of the National Bureau of Plant Genetic Resources at New Delhi.

The operational efficiency, low transaction costs and conservation potential of such a network will encourage their replication and implementation at State and National level. Thus, an effective integrated national gene management system can be built up.

The Community Gene Management System is being introduced in three predominantly tribal districts of Orissa, namely Koraput, Kandhamal and Kalahandi. The Koraput district is a primary centre of origin (particularly of the *aus* ecotype)

of rice. Though genetic variability in rice has been well chronicled, there is a need to purify the seeds of landraces, multiply and evaluate them as they are direct and indirect sources of valuable genes.

Among the millets, finger millet (*Eleusine coracana*) has been popular as a tribal crop for use as staple. *Sorghum* is another crop generally grown by the tribal families in their backyards and the grain are used as "pop" sorghum. The rich variability in "pop" sorghum needs to be conserved and used sustainably. Among the pulses (i.e., grain legumes), perennial types of *Cajanus cajan* are widely cultivated. They are well adapted to rainfed condition and poor soils.

The Kandhamal district is located in the central, Kalachandi in the south-western and Koraput in the southern region of Orissa State. These tribal districts have been chosen for fostering the growth of the first community-centered Integrated Gene Management System in India.

Science and Society : A new social contract

The primary partners in this project are the economically and socially underprivileged tribal women and men. In addition to the revitalization of the traditional conservation ethic of local communities, such a system will help to implement the conservation and equitable sharing provisions of the Conservation on Biological Diversity (particularly articles 8 and 15). The Community Gene Management Systems provides an opportunity for fostering symbiotic partnerships between rural/tribal women and men and scientists in areas like participatory breeding and the development of new varieties adapted to local conditions using novel genetic combinations provided by genetic enhancement centers.

B. Alien Species Invasion

Alien invasive species are posing a serious threat to biodiversity conservation worldwide. Such species include introduced weeds, invertebrate and

vertebrate pests and plant and animal diseases. The growing volume of trade and new trade routes are increasing the prospects for the unconscious introduction of alien invasive species. The problem is particularly serious in developing countries due to inadequate quarantine arrangements. The existing sanitary and phytosanitary measures are proving to be insufficient to eliminate the risk of introduction of invasive species through food grain shipments by "Aid agencies", as well as through trade in horticultural and agricultural products and animal pests. Article (8j) of CBD calls upon the parties to the Convention to "prevent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". The water hyacinth, which is a native of the Amazonian region, and which has now spread worldwide, is a good example of an aggressive alien invasive species. In many countries, thick mats of water hyacinth impede navigation, fisheries, displace native aquatic flora and fauna, and interfere with irrigation, dams and hydroelectric power generation.

The North eastern region of India is classified as a mega- biodiversity area. Unfortunately, this region has also become a "hot pot" area with reference to threats to biodiversity. The region is characterized by the continued prevalence of shifting cultivation leading to the depletion of forest resources. Alien invasive species like *Eupatorium*, *Mekenia* and *Lantana* have spread fast in the post-shifting cultivation areas. Unique mammals like *Mithun* are now finding it difficult to get adequate food, since the alien species are non- edible. This is one of the causes for the dwindling population of *Mithun*.

Every country, as proposed under Article (8) of CBD should develop a strategy for the prevention, control and ultimate eradication of alien invasive species. Biological control and where feasible, finding economic uses for such species,

will help in managing the menace posed by such species.

This is also an area where the opportunities provided by recombinant DNA technologies may help. The possibility of causing seed abortion through approaches popularly christened as "terminator mechanism" could be explored in the case of species such as *Parthenium* which also cause human health problems like dermatitis. Since such research may not be of interest to private sector R & D institutions, research on the control of alien invasive species through genetic modification techniques will have to be supported from public funds.

C. Genetic homogeneity

Genetic homogeneity associated with mono-cropping and modern agriculture leads to the replacement of large numbers of local varieties with a few high yielding strains. The dangerous consequences of covering large continuous areas with one or two genetic strains are now well known. Varietal diversification and crop rotations involving crops with non-overlapping pest sensitivity are important for sustainable agriculture. The transition from "Green Revolution" to an "Evergreen Revolution" involves the substitution of a commodity-centered approach to a farming systems approach. The farming systems approach involves the adoption of mixed farming (crop-livestock-fish) methodologies, based on an integrated natural resources conservation strategy. Participatory breeding including the use of novel genetic combinations arising from genomics and molecular breeding will help to combine advances in yield and quality with location-specific adaptation.

In most developing countries, particularly in India and China which have fifty per cent of the global farming population, continuous advances in farm productivity per units of land, water and energy are essential for sustainable food

security. Hence, there is need for developing and disseminating ecotechnologies, based on appropriate blends of traditional wisdom and technologies with bio-, information, space and renewable energy technologies. The ecological prudence of the past and the fruits of contemporary innovation can then be combined in a symbiotic manner.

With the growing privatization of plant breeding and expansion of proprietary science, it is important that an ecologically, economically and socially sustainable farming systems policy is developed for each agro-ecosystem. Such a policy will have to be developed jointly by farming families, official extension agencies and private sector companies. Unilateral introduction in large areas of one or two genetically modified strains of important food crops could cause irreparable harm in a few years' time both to food security and technological credibility. The pathway to an Ever-green Revolution on the farm is the adoption of integrated natural resource and gene management strategies.

SUMMARY AND CONCLUSIONS

Biodiversity Management : Transition from Social exclusion to inclusion

The threats to biodiversity arising from habitat destruction, alien species invasion and genetic homogeneity are increasing worldwide. While on the one hand, species extinction is taking place unabated, the realization that national and global food, health, livelihood and environmental security systems depend upon the conservation of biodiversity is also growing. Genomics and molecular breeding have opened up uncommon opportunities for creating novel genetic combinations which can help humankind to face new challenges arising from population increase and potential adverse changes in temperature, precipitation, ultraviolet-B radiation and sea level. A time has come when further

analyses of the causes of biodiversity loss alone are not enough. Effective and implementable methods of stopping further genetic erosion and fostering the rehabilitation of degraded ecosystems in megabiodiversity regions are the need of the hour. The remedial action which needs to be taken will have to be different in the following three methodologies of conservation.

1. *In situ* conservation through a national grid of protected areas

In this system of conservation, the following paradigm shift in management systems will be needed to ensure the achievement of goals for which the protected area networks exist.

Participatory Management of forests and habitats rich in biodiversity : Participatory systems of forest management involving both the forest dwellers and forest-dependent communities, and the government forest and wildlife departments will have to be fostered. Unless the livelihood security of local communities and the ecological security of protected areas are linked symbiotically, conservation will be a lost cause under conditions of poverty and deprivation. Local communities should have access to non-wood forest products, so that they develop an economic stake in the conservation of the forests.

Biosphere Trusts : Unique biosphere areas should be managed in a manner that all the stakeholders hold the Biosphere *in trust* for the generations yet to be born. Management of the Biosphere in a trusteeship mode will result in every group of stakeholders understanding their rights and responsibilities.

Harmonizing conservation and commercialization : Commercialization can become an important instrument of conservation, if commercial companies, such as pharmaceutical firms, will help rural and tribal families to cultivate on contract rate medicinal plants. This will help them to

source the raw material they need, without directly exploiting plants growing in forest canopies. Many important medicinal plants are now in the Red Data Books of several developing countries due to the unsustainable exploitation of such plants from the wild. Domestication of economically valuable Red Data Book species will help the cause of conservation, while at the same time meeting the needs of the commercial user.

2. *Ex situ* conservation

The management of Gene Banks, Botanical and Zoological Gardens and other *ex situ* conservation centres should be restructured so as to include the equity and ethics principles enshrined in the Convention on Biological Diversity (CBD). Provisions for prior informed content and equity in benefit sharing should be incorporated in voluntary codes of conduct. Gene Bank Managers should ensure that the accessions maintained by them for public good research are not used in a monopolistic manner. Material and Knowledge Transfer Agreements should form the basis for the supply of the material and knowledge gathered from the primary conservers of genetic resources and holders of traditional wisdom.

3. Community conservation

Urgent steps are needed, particularly in countries in which centres of diversity/origin of economic plants occur, for the revitalization of the *in situ* on-farm and *ex situ* on-farm conservation traditions of tribal and rural families. No further time should be lost in introducing a recognition and reward system for giving social prestige to the conservation ethics of farming and rural families. Since such recognition will be for entire communities and not individuals, community systems of recognition and reward should be developed. These should be accorded legal status through *sui generis* systems of Plant Variety Protection and Farmers' Rights. Community gene Funds based on a cess on all agricultural produce

can be established for rewarding communities who, through *in situ* on-farm conservation, have helped to maintain rich intra-specific variability in economic plants. Also, a Community Gene Management System comprising of field Gene Banks, Area Level Seed Banks and Community Gene Banks and Herbaria could be organised.

2. Alien species invasion

With increasing liberalization of trade in food grains and other agricultural commodities, the threat posed by alien species invasion to native biodiversity is increasing. A global strategy for the control of such invasion comprising the following collaborative steps is urgently needed.

- Improving sanitary and phytosanitary measures
- Introducing effective methods of biological control
- Finding economic uses for the invasive species, so that local communities can participate in their removal
- Mobilizing the new tools of genetic engineering to render such aggressive weeds sterile and thereby incapable of sexual propagation.

An integrated strategy for managing the problems created by alien species will help to eliminate the threats to native terrestrial and aquatic biodiversity.

Genetic engineering research to introduce infertility in aggressive invasive species like *Parthenium*, *Mekenia*, *Eupatorium*, and *Lantana* will have to be supported from public funds, since such research will not attract the attention of commercial companies. If research priorities are entirely dictated by market opportunities, orphans will continue to remain orphans. Scientific progress will then have little meaning for the poor and the public.

Avoiding genetic homogeneity in farming systems

Since the time modern plant breeding started with the rediscovery of Mendel's laws of inheritance in 1900, it has been known that genetic homogeneity in crop plants enhances genetic vulnerability to pests and diseases. There is therefore apprehension among scientists about the potential adverse impact of growing GM varieties of crops like rice, wheat, maize, potato and soybean over large contiguous areas. Commercial biotechnology companies recommend a refuge area in conjunction with pest resistant GM crops, in order to promote a resistance management strategy which will help to prevent the breakdown of pest resistance in the GM variety. Nevertheless, proprietary control of new strains may lead to a situation where the same genetic strain is widely grown.

Sustainable agriculture needs for its success a wide range of locally adapted varieties. Under the integrated gene management strategy, participatory breeding with farm families should be encouraged. Also, institutions working for public good should create novel genetic combinations under a well-designed pre-breeding programme and make such material available to grassroot farmer breeders who could incorporate the novel genetic traits for resistance to biotic and abiotic stresses in locally adapted varieties. Thus, advanced molecular breeding techniques can be brought to the service of resource poor farm families. In this manner, the techniques of pre-breeding and participatory breeding can be blended in a manner that the requirements of ecological, economic and social sustainability are concurrently satisfied.

GENDER DIMENSIONS OF BIODIVERSITY MANAGEMENT

It is important that in all the above aspects of a community-centered integrated gene

management strategy, gender roles in all aspects of genetic resources conservation, sustainable use and equitable sharing of benefits are given attention. Women in many developing countries are the primary seed selectors and savers. Their contributions to the evolution of a biodiversity conservation ethic should be fully recognized in any system which is designed to operationalized the equity in benefit sharing provisions of CBD.

If we promote worldwide a community-centered integrated gene management strategy, we will soon stop hearing about vanishing species and vanishing landscapes and habitats. None of the policies and procedures which I have suggested are difficult to implement. What is needed is as much interest in preventing species extinction and biodiversity loss, as in the chronicling of threats and preparation of Red Data Books.

Today, Governments and the scientific community often play the dominant role in organizing and managing structured *in situ* and *ex situ* conservation measures. By recognizing that conservation efforts represents a continuum, with rural and tribal families performing a vital function in preserving precious genetic variability in important plants and farm animals, we will be able to attend to all the links in the conservation chain. Community conservation is a value-added link in the conservation system, since local families not only conserve but add value to the conserved material through selection and information.

Let me conclude with the hope that if the 20th century was a period of understanding chronicling threats to biodiversity and bioresources both in land and water, the 21st century will be one where the threats are terminated and benefits harnessed for a better common present and future for humankind.

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STUDIES IN WORLD TOMATO (*Lycopersicon esculentum* Mill.) GERMPLASM COLLECTION: METHODOLOGY FOR ESTABLISHING A REPRESENTATIVE CORE SET USING CHARACTERIZATION DATA

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The present paper discusses the formation of a core set of tomato (*Lycopersicon esculentum* Mill.) germplasm comprising 2021 accessions and representing variability from 47 countries. Data on 41 morpho-agronomic and economic traits (qualitative as well as quantitative) scored/studied during summer season of 1990, 1991 and 1992 were used in the analysis. Principal Component Analysis (PCA) strategy was used to estimate the inertia and the corresponding Relative Contribution (RC) of each accession. Fourteen principal components with eigen values over 1 and explaining a total of 65 per cent of the variation were selected for computing the inertia and the relative contribution of each accession and improved method based on the RC score requiring low number of accessions to be sampled, was suggested for establishing the core set. The said method resulted into higher values of Shannon Diversity Index (SDI)/Coefficient of variation (CV) for 36 out of 41 characters scored. An optimum sample size of 140 was estimated on the basis of pooled diversity. A sample of 140 accessions (nearly 7% of the base collection) was finally selected for the final core set.

Key words: Tomato, *Lycopersicon esculentum*, germplasm, variability, diversity, principal component analysis, core set, Shannon Diversity Index, relative contribution

Cultivated tomato originated in the New World, while the Andean zone is likely to be the centre of origin of wild tomato. However, the domestication took place in Mexico. The most likely ancestor of cultivated tomato is the cherry tomato (*Lycopersicon esculentum* var. *cerasiforme*). According to Rick (1979), species of *Lycopersicon* were evolved via gene substitution. This fact is based on the systematic studies of *Lycopersicon* and closely related species of *Solanum*. Cultivars introduced from Latin America generally had exposed stigma, facilitating cross pollination. In the later stages, plants with high percentage of fruit set and with short style at the mouth of

anther tube were selected. Presently, cultivars with much shortened style exhibiting very high degree of self-pollination are available. In Peru, Ecuador, Colombia and Chile, cultivated tomatoes exhibit spontaneous crossing with *L. pimpinellifolium* indicating a close genetic relationship. This and other wild species e.g. *L. cheesmanii*, *L. chilense*, *L. hirsutum*, *L. peruvianum* and some *Solanum* species are, now included in tomato breeding programmes (Kalloo, 1991). Tomatoes are used directly as raw vegetables, in sandwiches, salads etc. several processed items like paste, soup, juices, ketchup, drinks, whole peeled tomatoes etc. are prepared on a large scale and enjoy high acceptance

as food ingredients. It is an important source of minerals and vitamins as well. The pulp and juice of the fruit is digestible and a mild aperient. It is a promoter of gastric secretion and blood purifier. It is also considered to be intestinal antiseptic and has culinary effect in the entire portion of alimentary canal.

The tomato plant is a classical breeding and genetic material for several reasons. A tremendous amount of genetic diversity exists in *Lycopersicon*. Normally, the cultivated tomato is self-pollinated but natural cross-pollination of 1.9 per cent to 26 per cent was recorded in various localities in India. There is abundant seed set under normal conditions and from full grown plant, 5,000 to 25,000 seeds can be obtained. Tomato has tremendous potential of heterosis of earliness, uniformity, total yield and resistance attributes. Thus, the cultivation of hybrid varieties is economical and remunerative, and therefore there is great demand of hybrid tomatoes. Tomato production is limited under conditions of low and high temperature. The fruit set is reduced when night temperatures exceed 21°C although tomatoes can set fruits at day temperature up to 38°C (Peet and Willit, 1993). The plants can not withstand severe frost. Temperature and light intensity affect the fruit setting, pigmentation and nutritive value of fruits (Chaudhary, 1967).

Greater the diversity in the germplasm material, the better is the chances for evolving promising and stable varieties. Attempts to identify cultivars with high productivity and quality potential were needed to cope with these challenges. Success of any breeding programme is largely dependent on the extent of genetic variability present in the population. The National Bureau of Plant Genetic Resources (NBPGR), over the years, has assembled *ca* 2900 germplasm lines from diverse agro-climatic zones of the world (from 47 countries) and from within India. This includes several wild species viz., *Lycopersicon*

pimpinellifolium, *L. hirsutum*, *L. chesmanii*, *L. peruvianum*, *L. glandulosum*, *L. chilense*, *L. chmielewskii*, *L. parviflorum*, *L. esculentum* var. *cerasiforme*, *L. hirsutum* var. *glabratum* and *L. parviflorum* var. *humifusum*. Thus considerable variability has been generated. Interestingly, introduction of germplasm of tomato has paved way for reasonably successful performance of different varieties in India. Some of the tomato varieties in India have been bred by selection technique. Considering the dearth of variation within *L. esculentum*, it is important to characterize and evaluate world collection of tomato genetic stocks on 41 agro-morphological, economic and yield contributing characters, so that breeders may utilize the same for deliberate breeding programme.

One of the major issue that Gene Bank managers (curators) face is the need to increase the accessibility of their collection to a large group of users. Developing procedure for reducing the size of a collection to a manageable and accessible level is becoming one of the most important issues in the management and utilization of large germplasm collections. Concept of developing core germplasm set as a minimal, yet diverse set, representing the diversity of the germplasm collection has attracted wide attention in recent years.

MATERIALS AND METHODS

Over *ca* 2900 germplasm lines were assembled, over the years, from diverse agro-climatic zones of the world (from 47 countries) and from within India by the NBPGR. These germplasm were evaluated under field conditions during hot summers (maximum temperature 38-42°C) at NBPGR Experimental Farm, Issapur (annual rainfall 400 mm; soil texture-sandy loam; pH 6.5-8.2) in Delhi. Each accession was grown in 2-row plot with rows 4 m long and 60 cm between rows, during summer

seasons of 1990, 1991 and 1992 in augmented block design and donors identified (Umesh Chandra and Thomas, 1993).

Developing a core set for efficient management of germplasm helps in maintaining comparatively fewer accessions rather than entire set of accessions. Principal Component Analysis (PCA) strategy was used to estimate the inertia and the corresponding relative contribution (RC) of each accession. Fourteen principal components with eigen values over 1 and explaining a total of 65 per cent the variation were selected for computing the inertia and relative contribution of each accession. An improved method based on RC score and requiring low number of accessions to be sampled, is suggested for establishing the core set.

Descriptors and Descriptor States used

C1: Plant growth habit : (1) Determinate : One or two leaves between flowering clusters and tip ends with an inflorescence; also known as self topping dwarf, (2) Indeterminate: Constancy of 3-4 leaves in between the flowering clusters, and tip does not end with an inflorescence (non-topping) and (3) Spreading: In this lateral axis terminates in a blossom which gives self topping. There appear less three leaves between the flower clusters, also known as self-topping bush/spreading type.

C2: Leaf Type : (1) Normal leaf and (2) Potato leaf

C3: Leaf Size : (1) Small, (2) Medium and (3) Large

C4: Leaf colour: (1) Light Green, (2) Green and (3) Dark Green

C5: Leaf pubescence: (1) Smooth and (2) Pubescent

C6: Leaf cover: (1) Poor, (2) Moderate, (3) Good and (4) Excellent

C7: Petiole pubescence: (1) Smooth and (2) Pubescent

C8: Stem type: (1) Round and (2) Angular

C9: Stem thickness: (1) Thin, (2) Medium and (3) Thick

C10: Stem pubescence: (1) Smooth and (2) Pubescent

C11: Flower size : (1) Small, (2) Medium and (3) Large

C12: Flower colour : (1) Deep yellow, (2) Light yellow and (3) Reddish yellow

C13: Style position: (1) Exserted and (2) Non-exserted

C14: Pistil type: (1) Branched and (2) Highly Branched

C15: Fruit size: (1) Small (cm), (2) Medium (5-8 cm) and (3) Large (8 cm)

C16: Fruit shape: (1) Round, (2) Oblong, (3) Flattened, (4) Pear shaped and (5) Bottle shaped

C17: Fruit surface: (1) Smooth and (2) Corrugated

C18: Blossom-end shape fruit: (1) Round and (2) Nippled

C19: Green stem-end of fruit: (1) Nil, (2) Indented, (3) Flat (Round) and (4) Pointed (Nippled)

C20: Type of fruit cracking: (1) None, (2) Slight, (3) Moderate and (4) Severe

C21: Fruit abnormalities: (1) Absent and (2) Present

C22: Type of placenta: (1) Small, (2) Medium and (3) Large

C23: Fruit firmness: (1) Soft, (2) Medium and (3) Firm

C24: Pulpiness: (1) Pulpy, (2) Highly pulpy and (3) Juicy

C25: Skin thickness: (1) Thin, (2) Medium and (3) Thick

C26: Seediness: (1) Low, (2) Medium and (3) High

C27: Time of maturity: (1) Synchronous: Attaining fruit maturity at a particular time and all plants in a row/plot attains maturity simultaneously and (2) Non synchronous: Attaining fruit maturity at a different time and all plants in a row/plot attains maturity at a different time

C28: Plant height (cm): Measured just before first harvest, in centimeters from the ground level to the tip of the primary branch on 5 random plants from the middle of the plot and data averaged.

C29: Number of primary branches (number): The number of branches that arise from the main stem were reckoned as primary branches. Total number of primary branches was counted at the time of first fruit harvest on 5 random plants from the middle of the plot and data averaged.

C30: Days to 50% flowering (days): Number of days taken from the date of transplanting to 50 % of plants flowered in the row/ plot. Stigma emergence on the main branch is considered as flowering.

C31: Days to first fruit set (days): As the fruits set for the first time in each plot, data recorded. Number of days

taken from the date of transplanting to date of first fruit set on 5 random plants were calculated in a row/ plot and data averaged.

C32: Days to first fruit harvest (days): As the fruits attained harvesting stage (turning stage) first time in each plot, the data recorded and averaged. Number of days taken from the date of transplanting to date of first fruit harvest on 5 random plants was calculated in a row/ plot.

C33: Days to maturity (days): Data recorded as the fruits attained maturity stage i.e., plants attained physiological maturity (80% maturity) in each plot. Number of days taken from the date of transplanting to date of plants attaining physiological maturity (80% maturity) in a row/ plot.

C34: Number of clusters per plant (number): Number of clusters found on a plant was counted in 5 random plants in a row / plot and data averaged.

C35: Number of flowers per cluster (number): Number of flowers found in the fourth cluster (on a plant) was counted in 5 randomly selected plants in a row / plot and data averaged.

C36: Number of fruits per cluster (number): Number of fruits found in the fourth cluster (on a plant) was counted in 5 randomly selected plants in a row / plot and data averaged.

C37: Number of fruits per plant (number): Number of fruits counted at each harvest and the cumulative total of all the harvests were taken as number of fruits per plant. The data were recorded on 5 randomly selected plants in a row / plot and averaged.

C38: Fruit yield per plant (g): The fruits picked in each harvest were weighed and cumulative yield was expressed in grams. The data were recorded on 5 randomly selected plants in a row / plot and averaged.

C39: Number of locules per plant: Actual number of locules. The number of locules was counted after cutting (section cut) the fruits transversely and counting the locules separated by septae. The data were recorded on 5 randomly selected plants in a row / plot and averaged.

C40: Pericarp thickness (mm): Measured in millimeters from an equatorial section of the fruit by using Vernier calipers. The data were recorded on 5 randomly selected fruits in a row / plot and averaged.

C41: Total soluble solids (%) : A hand refractometer was used for direct determination of total soluble solids-TSS (00 Brix) from fresh juice of fully ripened fruits. Mean of atleast 3 samples recorded as per solid's read directly from a Brix scale superimposed over the refractive index scale.

RESULTS AND DISCUSSION

Data on 41 morpho-agronomic traits of 2021 well-characterized accessions grown and evaluated at the NBPGR Farm, New Delhi, was used for sampling of the core accessions. Data pertained to 47 countries. There were 410 accessions whose source was not available. Owing to this lack of information, we did not initially classify the accessions on the basis of source country. The standardized data on all the 2021 accessions were subjected to principal component analysis (PCA). The information on (N x k) scores obtained from PCA were used for extracting the accessions accounting for maximum variability as described below. This technique has also been used by Hamon and Noirot, 1990; Hamon *et al.*, 1995; Mahajan *et al.*, 1996; Noirot *et al.*, 1996).

Selection of accessions through Principal Component Analysis

Principal component analysis and Factor analysis are basically dimension reduction techniques that analyze the interrelationships among the variables to study and/or assess the underlying structure of the given data. The principal components are uncorrelated among themselves and having variances equal to the eigen values of the sample correlation matrix. Also for any given $k < p$, principal components have the property that among all possible sets of k linear combinations of the variables, the set of first k principal components accounts for the maximum variation present in the given data. Hence this set is ideal choice to represent the original data on p variables by a smaller number of k variables as this set retains the maximum variation in the original data. Computationally obtaining principal components is essentially obtaining eigen values

and eigen vectors of a nonnegative definite matrix.

Let y_{ij} be the score through PCA for i^{th} ($i = 1, 2, 3, \dots, N$) accession and j^{th} ($j = 1, 2, 3, \dots, k$) principal components. The inertia of i^{th} accession is defined as:

$$P_i = \sum_{j=1}^k y_{ij}^2$$

Then the relative contribution of this i^{th} accession is given by $RC_i = P_i/(N \times k)$. The proposed selection procedure for obtaining the optimum number of accessions required for establishing core set consists of following steps:

i) Arrange the accessions in descending order of Relative Contribution

ii) Plot a curve between the Relative Contribution (RC) of each accession and the corresponding accession number.

iii) Select a point on the curve near the point of inflection where the fall in RC is almost low.

iv) Begin with the number of accessions equal to the number (point) selected in the above step (iii); compute the Shannon Diversity Index (SDI) for each qualitative descriptor and obtain the pooled diversity.

v) Repeat the step (iv) for a number of times with reduced number of accessions.

vi) Plot a curve between number of accessions and the pooled diversity. The peak point on the curve where the diversity is maximum, is thus, is the optimum point.

The base collection comprising 2021 accessions represented variability from 47 countries (Table 1). However, there were 410 accessions whose source was unknown. Frequency distribution of descriptor states (qualitative traits) for each descriptor is given in Table 2. The principal

Table 1. Source wise frequency distribution of 2011 accessions

Source Country	No. of Accessions	Source Country	No. of Accessions
Argentina	6	New Zealand	29
Australia	92	Nigeria	26
Baghdad	2	Peru	2
Brazil	9	Philippines	2
Bulgaria	29	Poland	18
Canada	48	Portugal	9
China	1	Russia	4
Cuba	2	South Africa	1
Cyprus	4	South America	1
Czechoslovakia	9	Spain	2
Denmark	20	Sri Lanka	2
France	9	Sudan	1
Ghana	2	Sweden	3
Netherlands	27	Switzerland	4
Hong Kong	3	Taiwan	269
Hungary	151	Tangerine	2
India	244	Trinidad	1
Israel	8	Turkey	2
Italy	20	UK	27
Japan	83	USA	382
Mauritius	9	Russia	36
Mexico	1	West Germany	1
Nepal	1	Yugoslavia	5
		Unknown	410

component analysis applied on all the 41 characters simultaneously resulted into 14 Principal components (Table 3, 4, 5) with eigen values greater than 1. All the components were used for computing the inertia of each accession. These components could account for nearly 64.6 pct of the total variation (Table 6). Fig. 1 suggested that the beyond 200 accessions (nearly 10% of the whole collection) the relative contribution of the succeeding accessions is very low and the curve becomes almost parallel to the X-axis.

Table 2. Frequency distribution of descriptor and descriptor states

Descriptor	Descriptor States (Codes)				
	1	2	3	4	5
C1	421	1373	227		
C2	1969	52			
C3	41	1666	314		
C4	459	1556	6		
C5	1914	107			
C6	748	952	280	41	
C7	42	1979			
C8	34	1987			
C9	12	1195	814		
C10	42	1979			
C11	431	1462	128		
C12	1143	813	65		
C13	1833	188			
C14	1365	656			
C15	472	1400	149		
C16	1417	271	268	44	21
C17	1872	149			
C18	1813	208			
C19	1314	667	38	2	
C20	1079	863	69	10	
C21	1568	453			
C22	490	1412	119		
C23	786	1082	153		
C24	941	425	655		
C25	579	1322	120		
C26	148	1540	333		
C27	627	1394			

Fig. 2 indicates that the captured diversity increases with the reduction in sample size and attains maximum value when the collection size is 140 (nearly 7% of the entire collection). Further reduction in sample size reduces the diversity.

The representativeness of sampled accessions was assessed by comparing its diversity with that

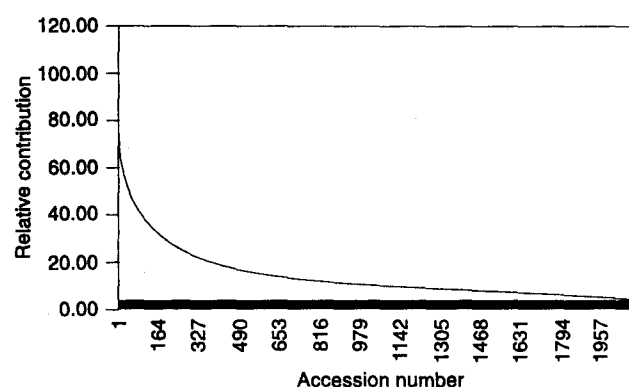


Fig. 1. Showing Relative Contribution (RC) of accessions

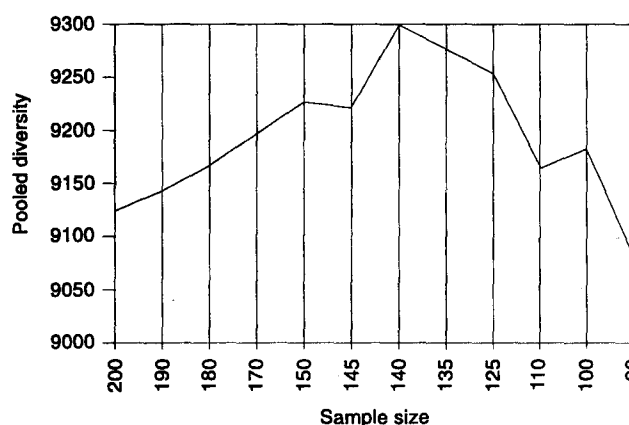


Fig. 2. Showing optimum sample size

of the whole collection for each individual qualitative and quantitative descriptor. The Shannon diversity indices and coefficients of variation (CV) for the selected accessions were compared with that of the whole collection (Table 7 and 8). The suggested procedure resulted into higher SDIs for all the qualitative characters for the core set; except for the characters, C5: Leaf Pubescence, C13: Style position and C21: Fruit abnormalities whose values were slightly lower than those of the base collection comprising of 2021 accessions (Table 7). In the same way, higher values of CV pct were observed for all the quantitative characters except for the characters, C29: Number of primary branches and C37: Number of fruits per plant (Table 8). The loss in variability in these two characters was only 0.3 per cent and 4 per cent respectively.

Table 3. Principal Components Analysis with factors 1-5

Variable	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5
ZC1	-.01727	.11697	.02091	.00399	.00328
ZC2	.06578	.01359	-.04280	.12593	.01789
ZC3	.11941	-.02252	.08863	.32221	-.04880
ZC4	.08385	.11162	.37542	-.09642	-.18432
ZC5	-.12907	-.30494	-.25057	.05897	-.00762
ZC6	.04036	.18401	.25143	.04372	.10891
ZC7	.15280	.03053	.44155	.14721	-.75408
ZC8	.03799	-.03794	.20105	.06319	-.35339
ZC9	.02167	.26414	.22138	.26874	-.18863
ZC10	.15584	.03130	.44459	.14682	-.75057
ZC11	.03761	-.21653	-.05658	.36056	.04980
ZC12	.03171	-.15566	.35131	.13670	.29935
ZC13	.07218	-.07871	.26527	-.20193	.09874
ZC14	.05208	-.04247	.56457	-.33540	.14818
ZC15	.17160	-.45169	.07564	.44467	-.09613
ZC16	.09848	-.22278	.10956	.15090	.12867
ZC17	.03091	-.04334	.30258	-.19684	.05841
ZC18	.01158	-.19777	.03568	-.04293	.30158
ZC19	.10802	-.07819	.56066	-.06523	.32530
ZC20	.03212	-.18951	.35335	-.00924	.42995
ZC21	.02936	.05746	.33992	.11367	.19394
ZC22	.20108	-.49340	.10719	.36221	-.06813
ZC23	.16043	-.51125	-.01847	.23077	-.11218
ZC24	-.07564	.56325	-.00324	-.26475	-.16231
ZC25	.17106	-.60379	.03900	.34739	.13330
ZC26	-.13295	.54090	-.04492	-.24066	-.07653
ZC27	-.00103	-.02601	-.56161	.39541	-.10855
ZC28	-.03952	.54194	.03386	.37358	-.02899
ZC29	-.10846	.40452	.11842	.36968	.24254
ZC30	.94755	.11910	-.12991	-.10897	.05477
ZC31	.94675	.12482	-.13040	-.10650	.05523
ZC32	.96162	.10110	-.10374	-.15047	.04799
ZC33	.88393	.09033	-.09160	-.18993	.00072
ZC34	.12609	.45398	-.22686	.53253	.05132
ZC35	.00795	.37624	.19402	.36301	.19840
ZC36	.03806	.40550	.36884	.25278	.27167
ZC37	.12999	.49157	-.00614	.53649	.18830
ZC38	-.00744	.00889	.21198	.06536	.01423
ZC39	.15244	-.10599	.18686	.29699	-.02243
ZC40	-.02622	-.05437	.07174	-.04834	-.03822
ZC41	-.02598	-.08423	.20610	-.09200	-.09005

Table 4. Principal Components Analysis with factors 6-10

Variable	Factor 6	Factor 7	Factor 8	Factor 9	Factor 10
ZC1	-.21438	-.23809	.30096	-.01353	-.30638
ZC2	.27992	.02987	.05714	.01391	.44183
ZC3	.08973	-.13451	.35419	-.07661	.06106
ZC4	-.13658	-.47919	-.20256	-.19798	.12741
ZC5	-.13387	.69274	.13857	.28332	.00108
ZC6	.31000	.23979	-.11482	.13154	.27704
ZC7	-.16979	.24988	.09639	-.03452	.10036
ZC8	-.11273	.10630	.12937	-.08899	-.37507
ZC9	.26534	-.13345	.04911	-.11567	-.23570
ZC10	-.16840	.24659	.10766	-.03780	.10330
ZC11	-.18983	-.01499	-.04091	-.03349	-.06246
ZC12	-.37052	.28168	-.06103	.06379	-.07478
ZC13	.05867	.04604	.33218	-.24714	-.07321
ZC14	.34042	.13954	-.09308	-.13656	-.16074
ZC15	.14796	-.01388	-.24396	.15043	.04506
ZC16	.37907	.04352	.20052	-.04445	.28390
ZC17	.23776	.04445	.10389	-.01335	.16226
ZC18	.15485	-.10539	.49925	-.17084	.06193
ZC19	-.06397	.03130	-.17865	-.04343	-.09905
ZC20	-.17902	.31823	-.04039	.03682	-.07435
ZC21	-.36344	-.16256	.05544	-.02520	.11346
ZC22	.15307	-.02940	-.16752	.09820	.06046
ZC23	.20435	-.11395	.15354	.01253	.21918
ZC24	.16192	-.02445	.05061	.11493	.13854
ZC25	.05096	-.08242	-.00478	-.10024	-.09034
ZC26	.00912	.09805	-.14803	.20284	.15510
ZC27	-.29947	-.12043	.08141	.04890	.07915
ZC28	.35874	.05246	-.15514	-.02992	-.08964
ZC29	-.04531	.20555	-.10795	.08658	-.02769
ZC30	-.03472	.06049	.00441	.05081	-.01859
ZC31	-.03423	.05689	.00607	.05421	-.01239
ZC32	-.05198	.01192	.00050	.04888	-.01033
ZC33	-.02193	-.02281	-.00465	.02443	-.01982
ZC34	.25775	.15670	.03010	-.16614	-.23165
ZC35	-.35860	-.15242	.16456	.17690	.27658
ZC36	-.28350	-.12844	.16585	.13339	.22799
ZC37	.12931	.12823	.13075	-.12130	-.16553
ZC38	.30782	-.09089	.15702	.41189	-.22939
ZC39	.02909	-.31441	-.46601	.10433	-.06554
ZC40	.11852	-.17802	.12800	.58458	-.17156
ZC41	.07468	-.22342	.20306	.52854	-.17191

Table 5. Principal Components Analysis with factors 11-14

Variable	Factor 11	Factor 12	Factor 13	Factor 14
ZC1	.27519	-.09256	-.39206	.17958
ZC2	-.47688	.37227	-.01913	.12349
ZC3	-.13686	.34131	-.32956	.36720
ZC4	.04269	-.01832	.17575	-.12734
ZC5	.03661	-.05468	.01144	.10502
ZC6	.13517	-.22795	.22482	.33286
ZC7	-.08404	-.02527	.02316	-.11069
ZC8	.21921	.03542	.03532	-.20690
ZC9	.13530	.09807	.11569	.31605
ZC10	-.07895	-.02293	.03298	-.11309
ZC11	.21342	.46416	.04631	-.31194
ZC12	.09866	.24550	.04017	-.07174
ZC13	-.16034	.02199	.20600	.01016
ZC14	-.14104	-.05099	-.10628	-.08065
ZC15	.07445	.10083	-.24624	-.04024
ZC16	.38800	.12893	-.05476	-.11294
ZC17	.44865	.11621	.06134	-.13767
ZC18	.12646	.05754	.20853	-.16969
ZC19	-.18152	.06006	-.04061	-.02254
ZC20	-.09337	.03704	-.10866	.03830
ZC21	-.02758	.14232	.14150	.30465
ZC22	.10606	-.09097	-.06648	-.10028
ZC23	.05121	-.32441	-.05650	.12220
ZC24	.03441	.20669	-.18627	-.08146
ZC25	-.08572	-.20974	.10414	.03264
ZC26	.20984	.12682	-.20991	-.01007
ZC27	.00438	.03377	.20887	-.02408
ZC28	.09962	-.11524	.21303	.00208
ZC29	.21742	.08092	.21618	.19327
ZC30	.02826	.00259	.01226	.03078
ZC31	.02637	.00146	.01362	.02941
ZC32	.02748	.00262	.01618	.01439
ZC33	.03209	.01324	.02125	-.00511
ZC34	-.14168	.04533	.04344	-.18203
ZC35	.02106	-.23178	-.06440	-.06782
ZC36	-.03634	-.26580	-.11514	-.12689
ZC37	-.19042	-.08220	-.07876	-.23800
ZC38	-.07209	-.12717	-.28694	-.15309
ZC39	.00745	.11293	-.07246	.09231
ZC40	-.16342	.10590	.26711	.09285
ZC41	-.05369	.11710	.30166	-.16876

Table 6. Showing communality, eigen value, pct variation and cumulative per cent variation

Variable	Communality	Factor	Eigen value	Var. (%)	Cum. (%)
ZC1	.57197	1	3.84925	9.4	9.4
ZC2	.68206	2	3.40634	8.3	17.7
ZC3	.66868	3	2.69180	6.6	24.3
ZC4	.59770	4	2.65213	6.5	30.7
ZC5	.78874	5	2.22184	5.4	36.1
ZC6	.60489	6	1.83974	4.5	40.6
ZC7	.94186	7	1.60741	3.9	44.6
ZC8	.45489	8	1.34412	3.3	47.8
ZC9	.52781	9	1.29622	3.2	51.0
ZC10	.94133	10	1.22907	3.0	54.0
ZC11	.58740	11	1.15952	2.8	56.8
ZC12	.56373	12	1.10312	2.7	59.5
ZC13	.38337	13	1.07180	2.6	62.1
ZC14	.68651	14	1.00640	2.5	64.6

Table 7. Shannon diversity index for the core and whole collection

Descriptor	SDI (Selected accessions)	SDI for all the accessions
C1	0.441733	0.362636
C2	0.272712	0.051929
C3	0.393863	0.229134
C4	0.339448	0.241139
C5	0.066914	0.089940
C6	0.544108	0.467036
C7	0.265295	0.043893
C8	0.217322	0.037091
C9	0.371877	0.307222
C10	0.262614	0.043893
C11	0.407211	0.320739
C12	0.341018	0.347085
C13	0.198969	0.134404
C14	0.286509	0.273728
C15	0.438325	0.341447
C16	0.584837	0.398271
C17	0.18358	0.114294
C18	0.279213	0.143947
C19	0.359853	0.312905
C20	0.358847	0.314724
C21	0.229616	0.231091
C22	0.432818	0.330429
C23	0.456173	0.389637
C24	0.474716	0.455566
C25	0.425291	0.348931
C26	0.380346	0.302125
C27	0.286509	0.268956

Shannon diversity index (SDI)

Table 8. Variability in the core-set accessions as well as full-set for quantitative descriptors

Desc- riptor	140 Accessions			2021 Accessions		
	C.V	Mini- mum	Maxi- mum	C.V	Mini- mum	Maxi- mum
C28	38.69	21.0	180.0	34.39	21.0	180.0
C29	25.69	3.0	8.0	25.98	2.0	10.0
C30	12.90	49.0	98.0	9.61	49.0	98.0
C31	11.56	56.0	106.0	8.59	55.0	106.0
C32	8.59	79.0	127.0	6.68	78.0	127.0
C33	8.18	96.0	142.0	6.83	95.0	142.0
C34	36.69	10.0	57.0	44.46	3.2	59.6
C35	16.46	3.0	9.0	15.33	3.0	9.0
C36	29.56	2.0	8.0	25.52	1.0	8.0
C37	52.79	3.0	235.3	56.78	3.0	250.0
C38	33.29	124.0	5600.0	28.06	124.0	6445.0
C39	36.70	2.0	6.0	30.36	2.0	6.0
C40	26.91	1.0	4.8	22.13	0.1	4.8
C41	16.68	1.200	6.8	14.32	1.2	6.800

Table 9. Showing accession No. source and the Relative Contribution (RC) of the top 140 accessions

S. No.	Accession No.	Source	RCx (2021×14) ⁻¹
1	EC251663	TAIWAN	109.82
2	EC104243	PHILIPPINES	87.03
3	LIA-722	—	82.77
4	EC99931	RUSSIA	80.75
5	EC251682	TAIWAN	79.71
6	EC1129	AUSTRALIA	75.96
7	EC2687	AUSTRALIA	75.82
8	EC251621	TAIWAN	74.29
9	EC278677	USA	72.80
10	PSR-468	INDIA	71.66
11	EC251683	TAIWAN	71.54
12	PSR-450	INDIA	70.34
13	EC212687	TAIWAN	69.93
14	EC3176	ARGENTINA	67.10

15	NC 57804	INDIA	67.07
16	PSR-444	INDIA	64.35
17	PSR-451	INDIA	64.10
18	EC13904	USA	61.33
19	EC154460	—	60.2
20	IC23585	INDIA	60.20
21	IC1703	INDIA	58.60
22	EC23885	—	58.15
23	EC125754	—	58.07
24	EC1703	—	57.73
25	EC162515	—	57.40
26	EC159036	BULGARIA	56.70
27	EC251711	TAIWAN	55.78
28	EC162508	—	55.66
29	IC159142	INDIA	55.31
30	EC12524	RUSSIA	54.38
31	EC162598	—	54.12
32	EC163670	—	53.61
33	2466-27	INDIA	53.19
34	EC164660	—	53.17
35	IC3709	INDIA	52.70
36	EC260308	—	52.14
37	PSR-446	INDIA	52.12
38	EC3709	—	52.10
39	EC163676	—	51.40
40	EC162518	—	51.09
41	EC164172	—	50.87
42	EC8739-1	SWITZERLAND	50.79
43	M28/81	INDIA	50.56
44	EC130053B	NEW ZEALAND	50.11
45	EC155996	—	49.81
46	EC159048	BULGARIA	49.37
47	EC56186	CANADA	48.36
48	EC164666	—	48.04
49	EC32271	—	48.03
50	U16-99	INDIA	47.97
51	IC127936	INDIA	47.84
52	EC32271	—	47.54

53	EC164686	—	47.33	91	EC232427	USA	34.95
54	EC164657	—	46.69	92	IC5539	INDIA	34.73
55	EC52062	USA	46.23	93	EC159993	USA	34.69
56	No 25	INDIA	45.74	94	DPP-3/204	INDIA	34.31
57	EC126766	RUSSIA	45.69	95	EC141817	—	33.43
58	EC241141	TAIWAN	45.64	96	EC35520	HUNGARY	33.19
59	EC125557	—	45.39	97	EC160193	BRAZIL	32.48
60	EC170372	USA	44.69	98	EC6592	USA	32.28
61	11309/P2	—	44.23	99	EC164859	—	32.05
62	PSR-439	INDIA	42.91	100	EC163616	—	31.99
63	A1	INDIA	41.54	101	EC177294	FRANCE	31.98
64	EC61742	CANADA	41.46	102	D.M.M.	—	31.67
65	EC69876	USA	41.35	103	IC6486	INDIA	31.62
66	EC130053	NEW ZEALAND	41.34	104	EC7286	AUSTRALIA	31.59
67	EC737/1	—	41.24	105	EC145549	TAIWAN	31.56
68	EC9208	—	40.89	106	EC491	UK	31.05
69	DM-3	INDIA	40.59	107	EC241147	TAIWAN	30.64
70	D-0449	INDIA	40.08	108	EC145623	RUSSIA	30.19
71	EC260637	NETHERLANDS	39.75	109	EC168004	TAIWAN	30.18
72	EC144295	NETHERLANDS	39.01	110	EC164853	—	30.13
73	IC 39786	INDIA	38.68	111	EC1087	—	29.37
74	EC168010	TAIWAN	38.66	112	EC276	—	29.33
75	EC57442	CANADA	38.59	113	EC27951	JAPAN	29.31
76	EC164846	—	38.15	114	EC35219	HUNGARY	29.09
77	IC1340	INDIA	37.33	115	EC241146	TAIWAN	28.91
78	EC241156	TAIWAN	37.30	116	EC145624	RUSSIA	28.71
79	EC161838	—	37.04	117	EC6592	USA	28.53
80	IC4197	INDIA	36.50	118	LA BONITA	—	28.48
81	EC16342	ITALY	36.27	119	PSR-438	INDIA	28.14
82	EC8822	DENMARK	36.07	120	EC163589	—	28.09
83	EC251679	TAIWAN	36.02	121	EC37302	USA	28.04
84	EC761	—	35.68	122	EC386504	—	28.00
85	EC232428	USA	35.42	123	EC159966	USA	27.96
86	EC27975	JAPAN	35.42	124	EC32612	DENMARK	27.94
87	EC23885-B	—	35.33	125	EC106281	USA	27.66
88	EC118282	HONG KONG	35.17	126	EC113838	TAIWAN	27.52
89	EC251680	TAIWAN	35.13	127	EC117381	USA	27.26
90	EC164677	—	35.05	128	EC50348	NIGERIA	27.20

129	EC141823	—	27.17
130	PSR-427	INDIA	27.00
131	EC26106	CANADA	26.90
132	EC164854	—	26.89
133	EC41243	USA	26.87
134	33/81-30	INDIA	26.79
135	EC129605/P2-1	NEW ZEALAND	26.73
136	EC162520	—	26.70
137	EC1148	AUSTRALIA	26.65
138	EC61691	USA	26.61
139	EC129594	NEW ZEALAND	26.59
140	EC31515	CZECHOSLOVAKIA	26.43

EC and IC numbers represent exotic collections obtained from other countries and indigenous collections from within India respectively and maintained at NBPGR, New Delhi, India

The purpose for a core collection is to select a small representative sample of genetic variation from a large germplasm collection to assist the germplasm curators and users. In the present study the, accessions in the representative core set constituted approximately 7 per cent of the whole collection. A sample fraction of 10 per cent has been proposed by Brown (1989a) as the optimum sample size. The optimum sample fraction, however, depends largely on the degree of redundancy among accessions and certain other factors (Yonezawa *et al.*, 1995). The reason for lower fraction in our case could be accounted for repeat introductions of the material from exotic sources in the past several years.

Higher values of indices (SDI) for majority of the qualitative characters in the selected entries as compared to the whole collection is indicative of better representation of the existent diversity by the selected accessions. The quantitative variability was also fairly represented by the selected accessions for almost all the characters. Our method of selecting accessions, slightly differs from the one suggested by Hamon and Noirot (1990). In the later method, we first search two accessions

with the highest relative contribution (RC) and simultaneously we go on adding accessions one by one with the next highest RC until the SDI on them approximately equates the corresponding values for the entire cluster. The accessions sampled from various-clusters within a cluster constitute the sample core subset. The accessions from various sample core sub-sets are pooled to form the final sample core set. Our method first locates a point on the RC curve (Fig. 1) where the fall in RC stabilizes. After locating the point on the RC curve, the peak point is located on the pooled diversity curve (Fig. 2) where the pooled diversity (sum or average of SDI of all the characters) is maximum. Our method resulted into higher values of SDI/CV for 36 characters out of 41 characters (Table 7 and 8) with lower number of accessions. For tomato core, an optimum sample size of 140 was estimated on the basis of pooled diversity. A sample of 140 accessions (nearly 7 % of the base collection of 2021 germplasm lines) was finally selected for the final core. Thus, the suggested method of selecting accessions can be safely used, even when the passport information is partially available or not available.

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RICE GERMPLASM DIVERSITY IN ARUNACHAL PRADESH

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Arunachal Pradesh, the land of rising sun, is a picturesque state of India located between 26°28' to 29°30'N latitudes and 91°30' to 97°30' E longitudes. The state is a continuous stretch of Eastern Himalayan range which is surrounded by Bhutan in the West, China in the North and Northeast Myanmar in the east and plains of Assam in the South and South-east direction. The splendid floral and faunal diversity of the state is gaining international recognition as a biosphere reserve of rare order. Arunachal Pradesh is predominantly a hilly terrain. The geographical area of the state is 83743 sq. km. out of which 51540 sq.km. area (61.7%) is under forest. The total conserved area is 19325 sq. km. The total population of state is 864558, out of which 94018 belong to farming families. The population density is 10 per sq. km. There are total 13 administrative districts comprising 3649 villages where 25 major tribal groups are dispersedly inhabited. About 60-70 dialects which are distinct from one another used by independent tribes.

Key words : Rice, germplas, diversity, landraces

The topography is highly varied and the environment ranges from tropical to Alpine (640-7090m). The total cropped area of the state is 220000 hectares. Rice is the principal food of the state, which grows mostly in jhoomland. The wet rice cultivation (1,21,800 ha.) is done in river bed areas or where sufficient water is available. Due to varied topography, altitude, rainfall and the cultural heritage of different ethnic tribes, the situation leads to preserve the various rice diversities in their respective areas. Nomenclature of each landrace of rice variety is maintained by the particular ethnic group. Cultivation of high yielding varieties (HYV) of rice is recent phenomena, introduced by the ICAR Research Complex for NEH Region, Basar Centre and by the state agriculture department. Otherwise, the major local diversities of rice are maintained by the local farmers themselves. The cultivation is practiced only once in a year, under rainfed

condition. Gravitational irrigation system is only practiced by the 'Apatanis' in the Apatani plateau at Ziro of Lower Subansiri district (Chowdhury *et al.*, 1993). The rice maturity duration is very lengthy which varies from 210 to 260 days due to high altitude (1600 m).

Ethnic Diversity

The ethnic diversity of the state attracts many anthropologists. The social structure, customs, culture and methods of various crop production, retention and preservation of indigenous crop germplasms are maintained by them in their own way and these are their age old practice. Conservation of crop germplasms is their traditional practice for survival. The various tribal communities are dominant in particular district. The ethnic diversity is directly related with crop germplasm diversity in respect of local nomenclature of particular variety, adaptability,

cultural practices of particular crop variety and the preference of cultivation over the local ecological condition as well as the heritage. Mere adoption of HYV do not convince them to grow, as they are much concerned over the food security. District-wise a list of major tribes of the state is given in Table 1.

Table 1. Major tribes of Arunachal Pradesh (Dominant in districtwise)

District	Tribes/Subtribes
Tawang	- <i>Monpa</i> (Tawang, Duhiang, Kolan), <i>Sherdukpen</i> .
West Kameng	- <i>Akas</i> , <i>Mijis</i> , <i>Monpa</i> , <i>Sherdukpen</i> , <i>Khowas</i> .
East Kameng, Western & Central parts of lower Subansiri, including Papumpare district	- <i>Bangni</i> , <i>Nissi</i> , <i>Nishang</i> , <i>Adi</i> , <i>Daflas</i> , <i>Solungs</i> , <i>Hill Miris</i> .

Eastern part of lower Subansiri	- <i>Apatanis</i> , <i>Nissi</i> , <i>Solungs</i>
Upper Subansiri	- <i>Tagins</i> , <i>Hill Miris</i> .
West Siang, Upper Siang, East Siang	- <i>Adi</i> group (included communities of <i>Pallibe</i> , <i>Mitan</i> , <i>Bori</i> , <i>Tagin</i> , <i>Gallong</i> , <i>Minyong</i> , <i>Karbe</i> , <i>Pasi</i> , <i>Pangis</i> , <i>Padam</i>) belongs to different spoken dialects.
Dibang Valley and Lohit	- <i>Mishmi</i> group (included communities of <i>Idu</i> , <i>Digaru</i> and <i>Miju</i>), <i>Khamptis</i> , <i>Deoris</i> , <i>Singphos</i> .
Changlang and Tirap	- <i>Nootes</i> , <i>Wancho</i> and <i>Tanges</i> , <i>Lisus</i> .

Rice cultivation

In comparison with area, the population density is less and thus the crop cultivation is also limited. Rice is the major cultivated crop

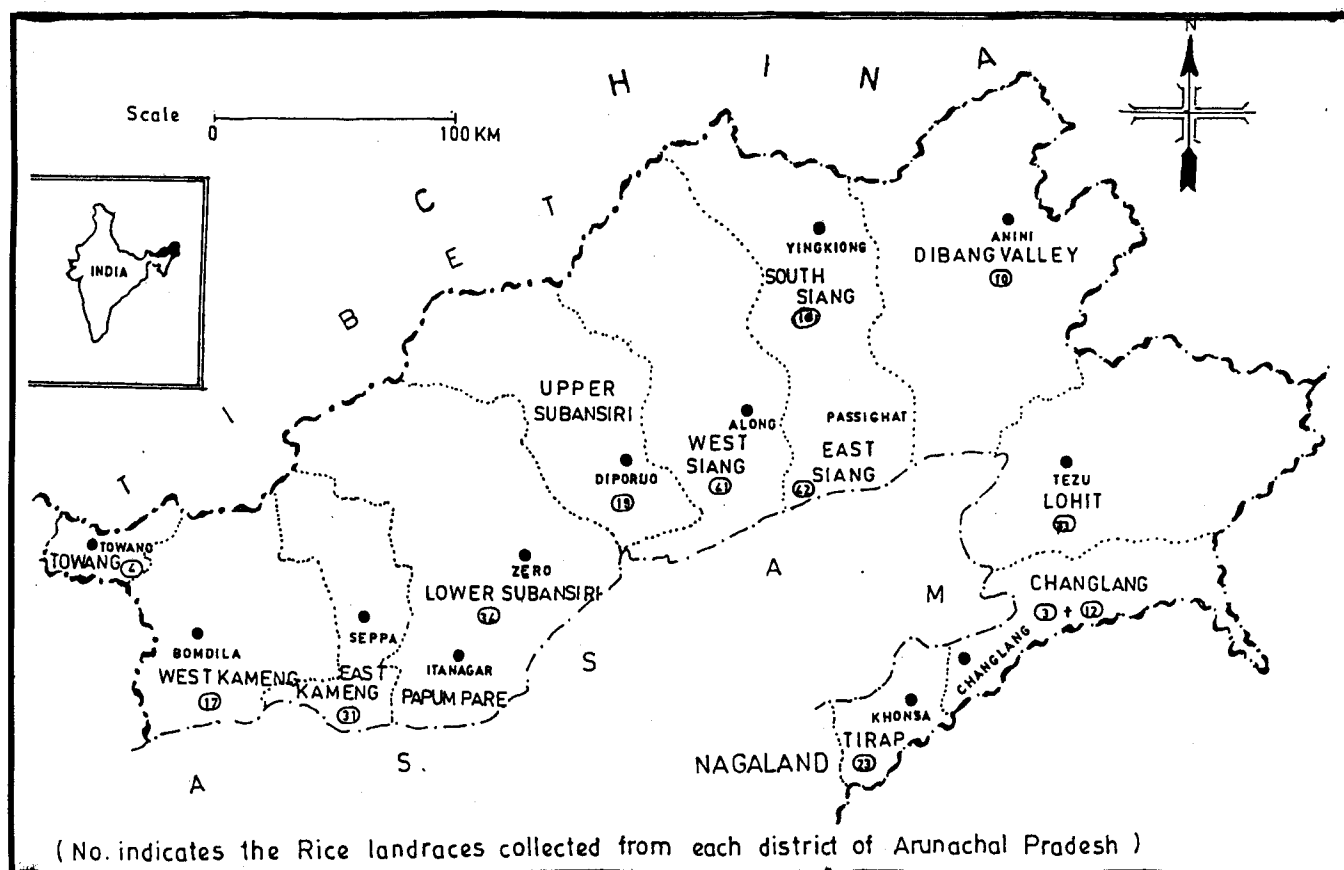


Fig. 1. Map of Arunachal Pradesh

which practiced in Jhoomland, plateaus, terraces and river bed areas. The Apatani plateau (near Ziro) is famous for well managed rice cultivation. At least 17 diverse rice landraces are cultivated in this area (1600 m.) following the indigenous method of cultivation. Due to the low temperature, the crop duration continues between 210-260 days, but the crop yield is 50-55 quintal/ha., in indigenous wet rice varieties. These varieties are short, bold grained with glutinous kernels. Harvesting of panicle is a local practice by the tribes and the spontaneous threshing is done in the field itself. Fungal diseases like blast, false smut and neck blast were observed in a few varieties.

Previous collection of Sharma *et al.* (1971) indicates that there were 1527 samples from this state and 757 accessions were maintained at Central Rice Research Institute (CRRI), Cuttack (Paroda and Sharma, 1986). Between 1987 to 1997, 14 field collection trips were conducted by the NBPGR, Shillong in various districts (Fig. 1) of

the state and 976 accessions of rice germplasm were collected (Ann. Report, NBPGR, Shillong). Approximately 300 accessions belong to local landraces. The *indica* vs. *japonica* races of rice characteristics were found in some pockets of the districts (Table 2). The *japonica* strains were thus collected from the pockets of Apatani plateau of Lower Subansiri, West Siang, East Siang, Yingkiong and Trap districts. The occurrence, of course, was very rare. The characteristics of *Japonica* race of rice are grains which lack dormancy, morphologically short and roundish, do not shatter easily, poor amylose content (10-20%), and with very compact panicles. A preliminary field characterisation of seven such identified accessions of *japonica* race of rice was carried out and the result is shown in Table 3.

Rice diversities collected from the Arunachal Pradesh

In course of the survey and collection of rice germplasms from NBPGR Regional Station, Shillong, landraces collected from the different

Table 3. Characterisation data on *Japonica* rice landrace accessions

Sl. No.	Accs. No.	NIC No.	Plant height (cm)	No. of tiller	Leaf L × B (cm)	No. of panicle	Panicle length (cm)	No. of grains/p anicle	5 Panicle Wt. (g)	A/AL	100 seed Wt. (g)	5-plant seed Wt. (g)	Days to maturity
1.	H-3167	NIC-22766	121.6	13.1	31 × 1.48	9.8	28.5	275.3	13	AL	1.7	100	180
2.	H-3163	NIC-22762	117.3	7.8	34 × 1.62	7.4	23.02	110.8	12.9	AL	2.4	42.5	140
3.	H-3168	NIC-22767	150.12	8.0	49 × 2.09	8.0	31.2	279.4	13.0	AL	1.7	53.5	149
4.	H-3097	NIC-22696	115.48	7.2	36 × 2.12	7.2	26.94	159.8	15.0	AL	2.4	42.3	158
5.	H-3045	NIC-22644	124.0	5.4	42.2 × 1.54	5.0	23.0	172.0	16.3	AL	2.7	70.0	156
6.	H-3177	NIC-22776	129.7	4.2	39.0 × 2.42	4.2	27.7	186.6	12.6	AL	2.1	31.0	148
7.	H-3283	Not assigned	136.5	3.0	55.18 × 2.6	3.0	29.06	226.8	15.8	A	2.7	75.0	126

districts of Arunachal Pradesh are listed below. The total number of collected rice landraces are also indicated in the Fig. 2.

District	Name of the rice landrace (s)
Tawang	: Kimin red, Tso-Monpa, Soneng-kharpa, Druk-pany.
West Kameng	: Salaw, Amtheburi, Mukme, Pangra, Holadban, Bali, Sing sung, Tapa, Bali, Nya, Nou, Yewang, rah, Nerara, Tangra, Grimcki, Nuh.
East Kameng	: Remi, Piyti, Namni, Taba Biwe, Lorry, Ralong, Adi, Tening, Naga-Am, Ningpung, Am- Tapu, Khilling, Longro, Mikka, Bengkor, Yarte, Lomok-longro, Bray- Am, Naga, Ralo, Machbung, Pucho, Rame, Choke, Mikar, Maland, Loro, Paki, Nimkuri, Yemone.
Papum Pare	: Nil
Lower Subansiri	: Pyapu, Pyapon, Puyi, Pyapi- pyakke, Pyapi, Pyatkogya, Pyatpyani, Pyaping-pyani, Kimin, B habeli- Joha, Bomo-Am, Tawa, Ellang-Emmo, Khilling-Am, Deiji-Am, Pyaping Pyapu, Empu-Arey, Omta, Kogya-Mepia, Tawa-Am, Ala-Amo, Ampo-Amo, Mipia- piyati, Piyapi-Mipia, Radhe-Amo, Puyaping, Emmo, Nishi-Mipia, Misa, Oye- impo, Ji-pyat, Pyat-pyare, Maina.
Upper Subansiri	: Pana, Tesa, Keli, Kesa, Bali Badam, Gapu, Pemin, Bey, Sarali, Mesa pale, Batkili, Pani-Am, Am- litchi, Am-Nginre, Am-kesa, Tarti, Puyi, Libo, Repu.
West Siang	: Ankor, Yabor, Bali, Yambor, Kimin, Yamruk, Tapey, Royla Amo, Hibar- hirpu, Yapu-pumik, Pirini, Simoi, Icehonse, Bali-lite, Tuinu, Wangkhan, Kesa, Yasing, Deppu, Mededeli, Nilony, Yaling, Pehi, Papuk, Mugme, Nipun, Tapa, Badap, Mukme, Yamuk, Lemuk, Milong, Laudulei, Buing, Yasing, Bee, Pehi, minre, Leli, Lite, Riyu.
Upper Siang	: Jagum, Tufum, Dangki, Ammong, Param, Gobuk Amo, Pinying, Pimlak, Retling, Amka, Jajum, Boi.
East Siang	: Amo, Amyong, Amte, Amiong, Oikey, Amolang, Amdang, Tafun, Riyum, Damruk, Kayor, Mingingin, Badap-Amker,

Amker, Yaber, Bali, Lamukh, Pelu, Rige-Kenmanyam, Neeli, Kuriang, Kerjok, Jajum, Joy-Bangla, Kokobaon, Amdang, Puyang, Amka, Neuli-Am, Katchia-Am, Riyu, Damruk, Dangum, Badsa-Am, Amkel, Kasiya, Kiyet, Khamti, Param, Takil, Ampang, Jorang.

Dibang Valley : Myu, Myun, Piyong, Mangtulu, Ahumang, Mangkatik, Jijuka, Bira, Kepu, Amiong.

Lohit : Keh, Khorcha, Khownamtok, Khawmakhe, Kamplanginang, Khownowjoma, Khamang, Khucho, Khomo, Kanchalmang, Khongkhat, Kya, Ketulu, Ke-Tapok, Ke-kalti, Holpeena, Deodhan, Toiyal, Ke-jaujong, Khownamtu, Khaupakhi, Khownujoha, Khojohalia, Mag-kampblu, Mang-kasai, Khongkhat, Khonu, Kepu, Khamang, Khono, Kharu, Khopsan, Kenah, Misi-maibong, Ke-bathah, Manzang, Loiliangha, Ke-mebo, Tongna, Champath, Khaomak-chow, Namah, Katiha, Peengha, Kehuseh, Kemebo, Ke-Jabiah, Ke-horpa, Khonow chew, Khao-kauli, ke-mee, Khoikan, Ke-mal, Ke-saw, Khaonon-Tek, Khanao- long, Khaojing, Khaojiling, Khapaki, Mukok-khae, Khomunon, Khano-heking, Khao- namtak, Myu, Myum, Piyong, Mangtulu, Khejohalai, Khowchi, Khow-nue- nak, Khow-un, khow-jee, Khow-neuri, Namtik-lung, Namtik-ann, Khow- nue, Khow-nue-chow, Khou-khot, Khow-namte, Khow-un-ann.

Changlang : Jajum, jumsing, Hamnyak.

Tirap : Champo, Chachiya, Tuisa, Jhasi, Khumyu, Jhakale, Kaleshi, Ajeja, Jhalu, Jhalugele, Ams, Janyu, Chichijanyu, Amuje, Jachene, Longkhap, Shimoi, Kanyak, Komi, Champe, Chamtim, Berguti

CONCLUSION

The hilly agro-ecosystem of the state of Arunachal Pradesh is based on the cultivation of a diversity of crops and varieties in time and space which have allowed traditional farmers to maximize harvest security by adopting their innovative methodology and limited resource input. While considering the rice genetic resources

and the farmers agricultural development, various genetic, ecological and socio-economic issues are interplay simultaneously within it. The Farmer's strategy is to minimize the risk by planting several species and varieties of crops that stabilizes yields over the long term, promotes diet diversity and maximize the returns under low levels of technology and limited resources (Harwood, 1979).

The traditional agro-ecosystems of Arunachal Pradesh containing rice crop population of variable and adapted landraces. The farmers goes for planting of multiple varieties which also allows both intraspecific and interspecific diversity and thus enhancing harvest security. The wide variability of primitive crop cultivars correspond well with the heterogeneity of the social and ecological environment (Brush, 1982). The statement is no way exception in case of *Khamptis* of Lohit Valley, where they are now maintaining at least, 75 rice land races. The conservation of *japonica* race of rice which are available in some pockets of the state are invaluable material for the country.

The best mode of approach to protect and conserve all these valuable rice landraces of Arunachal Pradesh would be

i) To gather the knowledge the gene pool of this ricelandraces and categorically collect and conserve them at first instance.

ii) Stress the value of traditional cultivation

practice towards the preservation of this native rice diversities on farmers field and to protect the local and adjacent ecological conditions. Farmers may be guided and encouraged in this direction.

iii) Monitoring the trend of genetic erosion at suitable time interval and at alarming situation, strategy for 'On-farm Conservation' can be adopted.

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SOME LESSER KNOWN MINOR CUCURBITACEOUS VEGETABLES : THEIR DISTRIBUTION, DIVERSITY AND USES

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Indian subcontinent is rich with genetic diversity in vegetable crops. Several species of family cucurbitaceae are available locally. Many of them are cultivated or found as semi-domesticated in the areas of their distribution. The most important crop genera included *Citrullus*, *Cucumis* and *Cucurbita*. Some genera like *Fevillea*, *Genostemma*, *Hemsleya*, *Actinostema*, *Bulbostemma*, *Cucumeropsis*, *Cucumis*, *Momordica*, *Siraitia*, *Telfairia*, *Hodgsonia*, *Gemnopetalum*, *Trichosanthes*, *Acanthosicyas*, *Bemincasa*, *Bryonia* or *Coccinia*, *Citrullus*, *Diplocyclos*, *Echallium*, *Praecitrullus*, *Cayaponia*, *Cucurbita*, *Sicana*, *Cyclanthera*, *Echinocystis* and *Sechium* and a large number of wild species have not only contributed towards food but also are rich genepool for important traits. These prized materials alongwith their close wild relative serve as genetic stocks by plant breeders for the development of improved vegetable varieties. With drastic increase in the world population, there is a great need to explore newer sources of vegetables. In this paper, diversity available in some minor/lesser known vegetables of the family Cucurbitaceae along with brief description has been illustrated. A check list of species with common names/local names, frequency and place of cultivation and uses is also included. This information will be very useful in screening newer sources of vegetables for present and future needs.

Key words : Cucurbitaceae, minor vegetables, *Fevillea*, *Cucumis*, *Trichosanthes*, *Cyclanthera*, *Sechium*, *Coccinia*, *Momordica*, distribution, diversity, uses

Minor cucurbitaceous vegetables have their importance mainly in the areas of their occurrence. Due to varied climate and physiography, enormous diversity has been developed in the Indian sub continent and tremendous wealth in terms of vegetables is available. Many species are edible. Some provide hard shelled fruits for vessels and musical instruments, whereas others are valuable as ornamental vines and for medicinal purposes. With ever increasing population and fast depletion of natural resources, it has become extremely important to diversify vegetable farming/cultivation to meet the present day's demands. The minor vegetables which have tremendous potential for commercial exploitation but remained ignored,

however, offer a good scope in the present situation. In cucurbitaceae, apart from cultivated vegetables, enormous diversity occurs in semi-domesticated and wild types in local pockets. Such types have been selected locally by native people as part of their routine vegetable requirements. Resilient and adaptive, many of them are tolerant to biotic adverse conditions and can grow on lands which are not suitable for other vegetables. They do not require a high input technology and can be raised with comparatively lower management costs. Several of them are very nutritious, remunerative and have often come to the rescue of people in times of crisis. Several species which possess medicinal

properties include *Fevillea cordifolia*, *Gynostemma pentaphyllum*, *Hemsleya amabilis* Diels, *Actinostemma tenerum* Griff., *Balbestemma paniculatum* (Maxim.) Franq. *Momordica balsamina* L; *Momordica cochinchinensis* (Lour), *Siraitia grosvenorii* (Swingle) Lu & Zhang, *Thaladiantha dubia* Burge, *Trichosanthes kirilowii* Maxim, *Trichosanthes lepiniana* (Naud) Cogn., *Bryonia alba* L, *Bryonia cretica* L., *Bryonia dioica* Jacq; *Citrullus colocynthis* (L.) Schrad, *Cayaponia ophthalmica* R.E. Schult and *Cayaponia Kathemathophora* R.E. Schult are used by pharmaceutical industries. Consumption of some minor vegetables is usually in the ripe or unripe/raw form, sliced, pickled, sun dried or made into drinks during extreme hot. In general, attention has not been given on specific breeding/evaluation programmes for these minor cucurbits so far. The wild genepool possess important traits and may be exploited both by direct selection or improvement through breeding. They also constitute a priceless reservoir that contain genes conferring better adaptation to stress environments and also resistance to disease and pests.

I. Distribution and Diversity

Indian sub continent is one out of 12 centres of diversity in crop plant in the world. Cucurbits comprise 118 genera and 825 species in the world, out of them 36 genera and 100 species are found in India. In this family, approximately 38 species are economically important and their cultivation is practised throughout the world from tropical to sub temperate zones. Many cultivated and wild species of cucurbitaceae dating back to pre historic times are associated with man's culture. Occurrence of genera alongwith species are given in Table 1.

Distribution and diversity is threatened due to several reasons: fragmentation of habitats, deforestation, over exploitation of the genetic resources, rapid changes in the hydrological regime

and land use patterns, soil degradation, air and water pollution, the adverse impact of development and increase in the population. As a result, a significant number of species are considered vulnerable and endangered.

Table 1. Global occurrence of some of the Cucurbits species

Crops	Species reported in the world	Species available in India
<i>Citrullus</i> species	4	2
<i>Coccinia</i> species	13	1
<i>Cucumis</i> species	26	5
<i>Luffa</i> species	5 (2 cultivated & 3 wild)	2
<i>Momordica</i> species	60	7
<i>Neoluffa</i> species	1	1
<i>Trichosanthes</i> species	44	22
<i>Lagenaria</i> species	6	1
<i>Cucurbita</i> species	27	4
<i>Sechium</i> species	8	1
<i>Benincasa</i> species	1	1

In different-ecological zones, several cucurbitaceous vegetables are distributed (Table 2a). The change of environmental conditions poses problems and therefore, an environment similar to the natural one should be selected for initial evaluation to understand the full potential of the crop. In this context, cultivation status, distribution status, genetic variability status, genetic erosion status and germplasm collection priority has to find a place in the existing or modified system or place (Table 2b).

II. Rare and endangered cucurbitaceous species in India

There are several species of cucurbitaceous vegetables which are being eroded at a fast pace. Some endangered cucurbitaceous species and its biogeographic zones are given in Table 2c.

Table 2a. Distribution of minor cucurbitaceous vegetables

Zones	Species
Western Himalaya	<i>Cucumis hardwickii</i> , <i>Cucumis trigonus</i> , <i>Luffa graveolens</i> , <i>Trichosanthes multiloba</i> and <i>Trichosanthes himalensis</i>
Eastern Himalaya	<i>Cucumis trigonus</i> , <i>Luffa graveolens</i> , <i>Neoluffa sikkimensis</i>
North-eastern region	<i>Cucumis hystrix</i> , <i>Cucumis trigonus</i> , <i>Luffa graveolens</i> , <i>Momordica cochinchinensis</i> , <i>Momordica macrophylla</i> , <i>Momordica subangulata</i> , <i>Trichosanthes cucumerina</i> , <i>Trichosanthes dioica</i> , <i>Trichosanthes dicaleosperma</i> , <i>Trichosanthes khasiana</i> , <i>Trichosanthes ovata</i> , <i>Trichosanthes truncata</i>
Gangetic plains	<i>Luffa echinata</i> , <i>Momordica cymbalaria</i> , <i>Momordica dioica</i> , <i>Momordica cochinchinensis</i>
Indus plains	<i>Momordica balsamina</i> , <i>Citrullus colocynthis</i> , <i>Cucumis prophetarum</i>
Western peninsular tract	<i>Cucumis setosus</i> , <i>Cucumis trigonus</i> , <i>Luffa graveolens</i> , <i>Momordica cochinchinensis</i> , <i>Momordica subangulata</i> ; <i>Trichosanthes anamalaensis</i> , <i>T. bracteata</i> , <i>T. cuspidata</i> , <i>T. horsfieldii</i> , <i>T. perottitiana</i> , <i>T. nerifolia</i> , <i>T. villosa</i>
Eastern peninsular tract	<i>Cucumis hystrix</i> , <i>C. setosus</i> , <i>Luffa acutangula</i> var. <i>amara</i> , <i>Luffa graveolens</i> , <i>Luffa umbellata</i> <i>M. cymbalurea</i> , <i>M. denticulata</i> , <i>Momordica dioica</i> , <i>M. cochinchinensis</i> , <i>Trichosanthes bracteata</i> , <i>Trichosanthes cordata</i> , <i>Trichosanthes lepiniana</i> , <i>Trichosanthes himalensis</i> , <i>Trichosanthes multiloba</i>

III. Specific adaptability

There are several cucurbitaceous vegetables which have specific adaptability in a particular area, where its existence is still maintained, for example, chow-chow (*Sechium edule*) has specific adaptation in Mizorum and *Momordica cochinchinensis* in Tripura, Assam and West Bengal, *Trichosanthes dioica* in Eastern U.P., Bihar and West Bengal, Sikkim and Assam valley etc. A detailed list of some vegetables which have been adapted to specific environment is listed in Table 2d.

Table 2b. Variability, distribution and genetic erosion status of Cucurbitaceous vegetables

Crop	Genera	CS	DS	GVS	GES	GCP
Bitter gourd	<i>Momordica</i> spp.	C	W	H	M	H
		W	W	H	H	H
Bottle gourd	<i>Langenaria</i> spp.	C	W	H	M	M
		W	W	H	M	M
Cucumber	<i>Cucumis</i> spp.	C	W	H	M	M
		W	W	H	H	H
Muskmelon	<i>Cucumis melo</i>	C	L	H	H	H
		W	L	H	H	H
Pointed gourd	<i>Trichosanthes</i> spp.	C	L	H	H	H
Pumpkin	<i>Cucurbita</i> spp.	C	W	H	M	H
Ridge gourd	<i>Luffa anguiculata</i>	C	W	H	H	H
		W	W	H	M	H
Round melon	<i>Praecitrullus fistulosus</i>	C	L	M	M	M
Snake gourd	<i>Trichosanthes cucumerina</i>	C	W	H	M	H
Snap melon	<i>Cucumis sativus</i> var. <i>momordica</i>	C	W	H	M	H
Sponge gourd	<i>Luffa cylindrica</i>	C	W	H	M	H
		W	W	H	M	H
Water melon	<i>Citrullus lanatus</i>	C	R	H	M	M
Ash gourd	<i>Benincasa hispida</i>	C	W	H	M	M

CS - Cultivation status, C = Cultivated, W = Wild; DS - Distribution status; W = Wide spread, R = Regional distribution, L = Localised; GVS - Germplasm variability status; H = High, M = Medium, L = Low; GES - Genetic erosion status; H = High, M = Medium, L = Low and GCP - Germplasm collection priority, H = High, M = Medium

Table 2c. Rare and endangered cucurbitaceous species

Cucurbitaceous species	Biogeographic zones
<i>Corallocarpus gracillipes</i> (Naud.) Cogn	WG
<i>Gomphogyne macrocarpa</i> Cogn	EH
<i>Indofevillea khasiana</i> Chatterjee	NE
<i>Luffa umbellata</i> (Kleir) Roem	WG
<i>Melothria amplexicaulis</i> Cogn	DP
<i>Momordica sub angulata</i> B1	DP, WG
<i>Trichosanthes lepiniana</i> (Naud.) Cogn	Dp, WG
<i>Trichosanthes perrottetiana</i> Cogn	WG
<i>Trichosanthes villosula</i> Cogn	DP, WG

Source - R.R. Rao. Biodiversity in India (Floristic Aspects) 281p. Bishen Singh and Mahendra Pal Singh, New Cannaught Place, Dehradun (Uttar Pradesh).

Table 2d. Specific adaptability of some cucurbitaceous vegetables

Crop	Area	Remarks
Chow-chow (<i>Sechium edule</i>)	Mizoram, Karnataka, Maharashtra	Highly naturalized
Parwal (<i>Trichosanthes dioica</i>)	Bihar, U.P., West Bengal	Abundant
Cucumber (<i>Cucumis sativus</i>)	Rajasthan, Himachal Pradesh, Maharashtra, Karnataka, Andhra Pradesh, Madhya Pradesh	Grown in winter-Hazipur (Bihar) specially in Son Ganga common area
Bittergourd (<i>Momordica charantia</i>)	Tamil Nadu, Kerala, U.P., Bihar, West Bengal, Maharashtra	Highly specific adaptability
Kakrol (<i>M. cochinchinensis</i>)	Mizoram, Tripura, West Bengal, Bihar, Vindhya hills of U.P.	A speciality favourite with natives
Watermelon (<i>Citrullus lanatus</i>)	Rajasthan, Punjab, Haryana, Western U.P., Karnataka, M.P.	Near river beds only; more sweetness in Arid zone
Musk melon (<i>Cucumis melo</i>)	Rajasthan, Eastern U.P., Punjab	More sweetness in Arid zone

IV. NBPGR's effort in germplasm collection

Important vegetable crops for which native diversity still need more emphasis for collection include *Cucumis* species, *Trichosanthes cucumerina*, *Trichosanthes dioica*, *Trichosanthes bracteata*, *Cucumis melo*, *Cucumis melo* var. *utilissimus*, *Coccinia cordifolia*, *Luffa* species, *Lagenaria siceraria*, *Citrullus colocynthes*, *Cucumis hardwickii*, *Cucumis hystris*, *Cucumis setosus*, *Momordica dioica*, *Momordica cochinchinensis*, on priority basis. The National Bureau of Plant Genetic Resources, New Delhi till date has collected following cucurbitaceous vegetables (Table 3).

Table 3. Collection of cucurbitaceous vegetables

Vegetables	Number of collection
Cucumber (<i>Cucumis sativus</i>)	294
Snap melon (<i>C. melo</i> var. <i>momordica</i>)	433
Musk melon (<i>C. melo</i>)	238
Kachri (<i>Cucumis callosus</i>)	156
Pumpkin (<i>Cucurbita moschata</i>)	795
Bottle gourd (<i>Lagenaria siceraria</i>)	664
Bitter gourd (<i>Momordica charantia</i>)	519
Sponge gourd (<i>Luffa cylindrica</i>)	566
Ridge gourd (<i>L. acutangula</i>)	335
Ash gourd (<i>Benincasa hispida</i>)	326
Pointed gourd (<i>Trichosanthes dioica</i>)	188
Ivy gourd (<i>Coccinea indica</i>)	15
Round gourd (<i>Citrullus fistulosus</i>)	49
Water melon (<i>Citrullus lanatus</i>)	75
Snake gourd (<i>Trichosanthes anguina</i>)	144

V. Economic species of lesser importance

1. *Momordica* species

In *Momordica* spp., total 60 species are reported world wide and out of them 7 species are available in India but only four species (*Momordica balsamina*, *Momordica charantia*, *Momordica cochinchinensis* and *Momordica dioica*) are commonly found. *M. balsamina* occurs in semi-dry north-western plains, northern parts of eastern and western Ghats. *Momordica dioica* and *Momordica cochinchinensis* occur in wild/semi wild form in gangetic plains. *M. cochinchinensis* is a dioecious, and perennial vegetable having tuberous roots. *M. subangulata* is also dioecious and perennial in nature with short annual vines. *M. littorea* is a new species of this group. It is also a dioecious climber with succulent trifoliate leaves and conspicuous bracteate flower. *Momordica foetida* is used in traditional medicine in Western Africa. *Momordica grosvenori* can be used for extraction of sweetener component, appeared to be glycoside (Lee, 1975). Immature tender fruits

of *Momordica balsamina* is used as vegetable or pickled. Fruits, leaves and roots of *Momordica* spp. is used as stomachic, carminative, antipurgative, regulating diabetes, leaf extracts as vermifuge, anthelmintic, appetizer, astringent and in liver and spleen disorders. Roots are useful in piles and urinary disorders.

2. *Luffa* species

Luffa gourd, essentially an old world genus, is considered to comprise 9 species in the world and out of this 7 species (*Luffa acutangula*, *Luffa cylindrica*, *L. echinata* (dioecious) *L. graveolens*, *L. hermaphrodita*, *L. tuberosa* and *L. umbellata* are native to India. There is ambiguity with regards to *L. tuberosa* and *L. umbellata* because they are considered synonym to species of *Momordica* and *Cucurbita* respectively (Chadha and Lal, 1993; Umesh Chandra, 1995). *Luffa cylindrica* is indigenous to India. *Luffa acutangula*, found in western, central and southern India, is regarded as wild form of cultivated species. *Luffa acutangula* var. *amara* occurs in peninsular India and is the wild relative of cultivated sponge gourd, *L. echinata* (Western Himalaya, Central India and Gangetic plains) and *L. graveolens* (considered a wild progenitor of *L. hermaphrodita* in Bihar and Sikkim) are potential species. A strikingly large number of variants evolved gradually through introgression and selection from wild forms, many of which are still cultivated in different parts of India. Ridgegourd or Ara Torai (*L. acutangula*), Kadvi Torai or Tita Jhinga (*L. acutangula* var. *amara* Roxb.), Satputia (*L. hermaphrodita*) and *L. echinata* Roxb. Bindal are also common. *L. forskohlii* (Harms) Heiser and Schilling, a wild form confined to Yamen but possibly developed from escapes of the cultivated forms. Fruits of Satputia (*L. hermaphrodita*) borne in cluster. This is commonly cultivated species in north eastern Uttar Pradesh and Bihar. Fruit is diuretic and expectorant in nature and used for curing biliousness, bronchitis, spleen diseases and ulcers.

Seed has the of emetic and cathartic property.

3. *Trichosanthes* spp.

In *Trichosanthes*, total 44 species have been reported and out of them 22 species occur in India. The major zone of species concentration are:

- a) Along the Malabar coast in Western Ghats
- b) Low and medium elevation zones in Eastern Ghats
- c) North-eastern hill region.

The wild species can be found along forest edges and in open forests upto 1000 m altitude. *Trichosanthes cucumerina* occurs wild in the total zone of concentration as stated above. It is an ancient cultivar. Only occasionally, it is cultivated as vegetable. *Trichosanthes ovigera* Blume is another important species. Its boiled fruits are eaten as a dish with rice. Starch of the tuber is sometimes extracted and is quite useful product for industries. Young fruits of *Trichosanthes villosa* are also eaten after boiling. Its sap from the leaves is used to cure dysentery, pounded leaves are applied on the body to reduce fever and lower down the pain of swollen legs. Till now, *Trichosanthes* remained a minor cucurbitaceous vegetable in South-East Asia. Adequate investigation of the wild species might reveal desirable characteristics of interest for improvement for domestication of the species.

4. *Citrullus* species

According to (FAO), watermelon is one of the world's most popular cucurbit. In *Citrullus*, 4 species has been reported so far and out of these 2 species are available in India. *Citrullus lanatus* is commonly cultivated species. *Citrullus colocynthis* - a perennial species exhibits much variation in north-western plains, central and southern India, where it is a potential crop. This is a vigorous West African plant, very similar in general appearance and habit to watermelons and

cultivated in the same way. The fruits are allowed to mature. Seeds are used as edible flour and cooking oil (Esquinas - Alcazar and Gulic, 1983). Sub species *mucospermus* is supposed to be the wild form of *Citrullus* having small fruits and white, bitter flesh especially important for its large, protein-rich seeds. *Citrullus ecirrhosus* is a perennial species, without tendrils and with extreme bitter fruits, adapted to the extreme climatic conditions of the desert. Elevations up to 1000 m normally provides suitable conditions for growth although excessive high temperature of more than 30°C may be harmful, reducing the degree of fertilization. Wild form of *Citrullus* spp are found in the dry sandy areas of South Africa (mainly in the Kalahari desert).

5. *Praecitrullus fistulosus*

Tinda (*Praecitrullus fistulosus*) Stocks Pang. is an important monospecific genus and *Praecitrullus* group and confined to the drier regions of South Asia. It is commonly known as round melon. Immature fruits are cooked as vegetable. Fruits are having high nutritional value hence this potential crop is becoming very popular among vegetable growers. Due to its keeping quality, it may be an excellent export oriented vegetable. The small round fruits up to 10 cm in diameter can be canned as a preserved vegetable. It may be used for the preparation of pickles or candies. The seeds are parched and eaten. The fruit juice has a cooling effect. It is helpful during typhus fever, infection of urinary organs and hepatitis.

6. *Cucumis* species

In *Cucumis* species, total 30 species are reported so far which are distributed over two geographically distinct areas but in India, according to Chakravarty (1982), out of these 6 species are available. Five wild species of *Cucumis* included *C. agrestis*, *C. hystrix*, *C. setosus*, *C. prophetarum* and *C. hardwickii*. *C. callosus* occurs mainly in

Punjab, Himachal Pradesh, Rajasthan, Uttar Pradesh, Bihar and Tamil Nadu. Wild related species of *C. sativus* is *C. hardwickii* and *C. trigonus*. *C. hardwickii* is found wild in foothills of NW Himalayas and southern hills, *C. setosus* endemic to Maharashtra; *C. prophetarum* to Sirohi (Abu) of Rajasthan, Gujarat, Maharashtra and Tamil Nadu; *C. hystrix* to Meghalaya, Assam and Mizoram. *C. setosus* is the only cultivated species indigenous to India (Umesh Chandra and Koppar, 1992). West Indian Gherkin (*Cucumis anguria* (L.) var. *anguria*) is an annual. The immature young fruits are used as salad, pickles and also used as cooked vegetables. It is a heavy yielder in comparison to general cucumber (*C. sativus*). Another species, which is having economic value is Kachari (*Cucumis callosus*). Its immature tender fruits and semi ripe fruits are used as vegetables, pickles etc. Snapmelon (*Cucumis melo* var. *momordica*) - commonly called as phoot under *Cucumis* group is very potential vegetable. Its productions and popularity is largely limited to India. Its immature fruits are used for cooking and mature fruits are consumed like muskmelon by adding little amount of sugar. It is a totally rainfed vegetable crops and farmers grow it as a inter-crop in maize, jowar, bajra etc. *C. ficifolius*, *C. prophetarum*, *C. saculeuxii*, *C. quintanilhae* and *C. zeyheri* are monoecious perennial *Cucumis* spp., whereas *C. asper*, *C. figarei*, *C. globosus*, *C. heptadactylis*, *C. hirsutus* and *C. meeusei* are considered as dioecious perennial *Cucumis* spp. *Cucumis melo* L var. *conomon* is rapid growing species and tolerant to high temperature and relatively high rainfall. *Cucumis hardwickii* is an annual monoecious species resembling *Cucumis sativus*. It hybridizes with *Cucumis sativus* producing a fertile F₁. *Cucumis hardwickii* plants are typically slow growing in early stage of growth and remain vegetative for extended period of time. After the slow growth period, vine developed at fast rate and sets large number of fruits per plant than *C. sativus*.

7. *Coccinia* species

The genus *Coccinia* with 30 species, is confined to tropical Africa. In India, *Coccinia cordifolia* is commonly grown as a cultivated type. Fruits and young shoots are used as vegetable. It is also becoming popular as a salad. It is a potential crop among the growers of tropical belt. Due to heavy yield and continuous fruiting for longer period and good transportation ability, farmers can earn a lot by this minor vegetable. *Coccinia wightiana* (Roem.) is considered as wild relative of *C. cordifolia*.

8. *Cyclanthera* species

This genus includes about 30 species, all are native to the neotropics. Under *Cyclanthera* spp. group, *Cyclanthera pedata* (L.) Schrad is a perennial and very nutritious vegetable. It can be grown as an annual. Young fruits having thick and fleshy tissue are eaten, raw or cooked. It is highly productive and potential for wide use in high altitude cultivation. The seeds are obtained from the older fruits; the seed cavity is suitable for stuffing. The closely related species *C. brachystachia* (Ser.) Cogn. (synonym *C. explodens* Naudin) is also cultivated for its edible fruits. It occurs in Nepal and South Taiwan.

9. *Benincasa* species

Ashgourd (*Benincasa hispida* (Thumb.) Cogn.) is the most important genus of Cucurbitaceae family and is widely distributed throughout tropical Asia. It has been reported to occur in the wild form in Indonesia (Java) (Purseglove, 1974). The young leaves and flower buds both immature and mature seeds are consumed. The main product of ashgourd is the mature fleshy fruit. Fruits are mostly used by confectioner in preparing delicious sweet candy, locally called 'Petha'. Due to long storage capacity, farmers usually fetch high price in the market. Its tender fruits are used for cooking and in making Bari (ripe fruits flesh

mixed with soaked and ground Urid dal, spices etc.) of fully matured fruits. No wild related species are known. Relatively high temperature and moderate rainfall seem to be suitable for its growth. The fruit is a good source of carbohydrate, Vitamin A and C and minerals (Randhawa *et al.*, 1983). An enzyme extracted from ashgourd juice can be used in place of calf rennet for producing cheddar cheese (Gupta and Eskin, 1977). It is also used to cure several ailments. Its use in Ayurvedic and naturopathy system of medicine is also reported. (Ramesh *et al.*, 1989 and Chandrasekhar *et al.*, 1989).

10. *Solena* species

Among minor vegetable of cucurbitaceae family, 'Bankunari' (*Solena amplexicaulis* (Lamk.) Gandhi is very nutritious and well known for medicinal value. It is synonym of *Melothria heterophylla* (Lour.) Cogn or *Solena heterophylla* Lour. It is a dioecious and climbing herb. The upper portion of vine dries every year but underground rhizomes sprout during rainy season. It is a very rare vegetable tasty and widely distributed in Bihar, West Bengal, Assam, Tripura, Kerala and U.P. hills up to an elevation of 2100 m. It needs domestication on priority basis.

11. *Telfairia* species

Genus *Telfairia* has 3 species and all are distributed in Tropical Africa. Under *Telfairia* group, two species *Telfairia occidentalis* Hook. f (fluted gourd) and *Telfairia pedata* (Sm. ex. Sims) Hook. (Oyster nut) are of economic importance. *Telfairia pedata* is a very large dioecious climber. Leaves and shoots are used as vegetable and its edible, aromatic seed has many uses. Its adaptation and cultivation is very common in humid tropics. Seeds of *Telfairia pedata* is a potential substitute for almonds. The fiber from the stem is used for making cords.

12. *Hodgsonia* spp

Hodgsonia spp. and its subtribe are monospecific. It is distributed in Indo-Malayan region. *Hodgsonia macrocarpa* is under cultivation to a limited extent in south and south-east Asia. Immature fruits are used as vegetables and seed for cooking oil.

13. *Lagenaria* spp.

Under genus *Lagenaria*, six species are reported so far. *Lagenaria siceraria* (bottle gourd) is generally cultivated species. All other species are wild, perennial and dioecious in nature. Its immature tender fruits are used as vegetables but dry shells are used for making bowls, bottles, containers, float for fishing nets, pipes and musical instruments. From seeds, edible oil is also extracted. It has a cooling, cardiogenic and diuretic properties. It is also useful in controlling asthma, bronchitis, inflammation and ulcer.

14. *Sicana* spp.

Under *Sicana* genera, three species are reported and all are distributed in the neotropics. Among them, *Sicana odorifera* (Vell.) Naud. (Casabanana) is under cultivation to a very limited area in central and northern parts of South America. Its fruits are quite useful as a dessert.

15. *Cucumeropsis* spp.

Cucumeropsis spp. is a monospecific genus and widely distributed in tropical West Africa. An edible oil is being extracted from *Cucumeropsis manii* Naud. (Egusi melon) and the fruits are used as vegetable when tender. It is a potential crop of tropics (Esquinas-Alcazar and Gulic, 1983).

16. *Cucurbita* species

The genus *Cucurbita* has 27 species, five of which are cultivated. It has stored carbohydrate, vitamin C, minerals and carotene. Its both mature

and immature fruits are used as vegetables. *Cucurbita ficifolia* - a vigorous perennial trailing herb is under cultivation since 4000-3000 BC. Its leaves are prickly broad, usually lobed and seeds are edible. Though buffalo gourd (*Cucurbita foetidissima* H.B. & K), a potential minor cucurbitaceous vegetable is a native of semi arid regions of the Western North America and Mexico, and is now well adapted to desert environment of India. It is drought resistant. Its seeds are rich in oil and proteins and roots have more starch. It has been also utilized as food, used in soap, shampoo, medicine and as stain remover since 1000 years. *Cucurbita cucadorensis* proves to be resistant to the most important and common diseases of *Cucurbita pepo*.

17. *Sechium* species

Chow-chow or Chayote (*Sechium edule* Sw.) is now under cultivation in India. Its local cultivars are commonly grown in the coastal and low hills (1000-2000 m) of Maharashtra, Karnataka, Tamil Nadu and North-Eastern Hill Regions. Unlike other seeded cucurbits, chow-chow has only one seed in the fruit with viviparous germination. Fruits are fleshy and pyriform with longitudinal furrows. Almost all parts of chow-chow are edible, young leaves and shoots and tendrils are cooked as green vegetables. Unripe fruits are either fried or cooked like bottle gourd. Being rich in calcium (170-140 mg/100 g), fruits of chow-chow are a good supplement in a tropical diet. The starchy roots are reasonably sweet in taste.

VI. Ethnobotanical uses

Wild plants of economic value have played an important role in the life of tribal people. Several local cucurbitaceous vegetable and under ground roots are regular part of their diet. They are collected directly from the wild or cultivated/protected as backyard cultigens by the

Table 4. Ethnic uses of cucurbitaceous vegetable species

Common Name	Botanical Name	Frequency	Place of cultivation	Usages
Antidote vine	<i>Fevillea cordifolia</i>	Rare	Neotropics	Medicinal
Jiao-gu-lan	<i>Gynostemma pentaphyllum</i>	Localized	Asia	Medicinal
Luo-ago-di	<i>Hemsleya amabilis</i> Diels	Localized	Asia	Medicinal
He-zi-cai	<i>Actinostemma tenerum</i> Griff	Localized	Asia	Medicinal
Pseudo-tritillary	<i>Balbostemma paniculatum</i>	Localized	Asia	Medicinal
White seed melon	<i>Cucumeropsis mannii</i> Naud	Localized	Africa	Food
Bur gherkin	<i>Cucumis anguria</i> L.	Localized	Wide spread	Food
Teasel gourd	<i>Cucumis dipsaceus</i> Ehrenb. ex.	Sporadic	Wide spread	Ornamental
African horned cucumber	<i>Cucumis metuliferus</i> E. Mey ex. Naud	Sporadic	Wide spread	Food
Sponge plant	<i>Momordica angustisepala</i> Harms	Rare	Neotropics	Utilitarian
Balsam apple	<i>Monordica balsamina</i> L.	Frequent	Wide spread	Medicinal
Cochin chin gourd	<i>Monordica cochinchinensis</i> (Lour.) Spreng	Sporadic	Wide spread	Medicinal
Kaksa	<i>Momordica cymbalaria</i> Frenzl. ex. Hork	Rare	Old world	Food
Luo-han guo	<i>Siraitia grosvenorii</i> (Swingle) Lu & Zhang	Localized	Asia	Food
Red hail stone	<i>Thladiantha dubia</i> Bunge	Localized	Wide spread	Medicinal, ornamental
Fluted pumpkin	<i>Telfairia occidentalis</i> Hook f.	Localized	Africa	Food
oyster nut	<i>Telfairia pedata</i> (Sims) Hook	Localized	Africa	Food
Hard plant	<i>Hodgsonia macrocarpa</i> (Bl.) Cogn	Infrequent	Asia	Food
—	<i>Gymnopetalum cochinchinensis</i> (Lour.) Kurz.	Rare	Asia	Food
Snake gourd	<i>Trichosanthes cucumerina</i> L.	Frequent	Widespread	Food
Chinese Snake gourd	<i>Trichosanthes kirilowii</i> Maxim.	Localized	Asia	Medicinal
Indreni	<i>Trichosanthes lepiniana</i> (Naud.) Cogn.	Localized	Asia	Medicinal
Japanese Snake gourd	<i>Trichosanthes ovigera</i> Blume	Frequent	Asia	Food
Mi-Mao-qua-lou	<i>Trichosanthes villosa</i> Blume	Localized	Asia	Food
Inara	<i>Acanthosicyos horridus</i> Wel. ex Hook. f.	Localized	Asia	Food
Wax gourd	<i>Benincasa hispida</i> (Thumb.) Cogn.	Frequent	Widespread	Food
Bryoni	<i>Bryonia alba</i> L.	Sporadic	Widespread	Medicinal
Bryoni	<i>Bruonia cretica</i> L.	Localized	Old world	Medicinal
Bryoni	<i>Bryonia dioica</i> Jacq.	Sporadic	Widespread	Medicinal
Colocynth	<i>Citrullus colocynthis</i> (L.) Schrad	Sporadic	Widespread	Medicinal
Ivy gourd	<i>Coccinia abyssinica</i> (L.) Cogn.	Localized	Africa	Food
—	<i>Coccinia grandis</i> (L.) Voigt.	Sporadic	Widespread	Food
Lollipop climber	<i>Diplocyclos palmatus</i> (L.) C. Jeffery	Localized	Old world	Ornamental
Squirting cucumber	<i>Ecballium elaterium</i> (L.) A. Rich.	Sporadic	Old world	Ornamental
Round melon	<i>Praecitrullus fistulosus</i> (Stocks) Pang	Localized	Asia	Food
—	<i>Cayaponia kathermatophora</i> R.E. Schult.	Rare	Neotropics	Ornamental
—	<i>Cayaponia ophthalmica</i> R.E. Schult.	Rare	Neotropics	Medicinal
Malabar gourd	<i>Cucurbita ficifolia</i> Bouche	Localized	Widespread	Food
Casabanana	<i>Sicana odorifera</i> (Vell.) Naud.	Sporadic	Neotropics	Food
Stuffing cucumber	<i>Cyclanthera brachybotys</i> (Poepp. & Endl.) Cogn.	Sporadic	Neotropics	Food
Stuffing cucumber	<i>Cyclanthera explodens</i> Naud.	Localized	Neotropics	Food
Stuffing cucumber	<i>Cyclanthera pedata</i>	Sporadic	Widespread	Ornamental
Wild cucumber	<i>Echinocystis lobata</i> (Michx.) Torr. & Gray	Sporadic	Widespread	Ornamental
Chayote	<i>Sechium edule</i> (Jacq.) Swartz	Common	Widespread	Food
Chayote	<i>Sechium tacaco</i> (Pitt.) C. Jeffrey	Localized	Neotropics	Food

native people which include species viz., *Citrullus*, *Momordica*, *Trichosanthes*, *Fevillea*, *Genostemma*, *Hemsleya*, *Bulbostemma*, *Thaladiantha*, *Bryonia*, *Cayaponia*, which commonly occur in areas surrounding local habitation. Human beings have utilized plants as the main source of medicine and have learned much about the avoidance and curing illness through the consumption and application of plants and their products. Plants contain thousands of compounds, a few are beneficial and most have functions that are still unknown. For example buffalo-gourd has been utilized by man as food and medicine since 1000 years. These tribals use these species in herbal therapy also since the beginning of human history (Tables 4 & 5).

Table 5. Some specific medicinal uses

Vegetables	Medicinal properties
1. <i>Momordica</i> spp.	Hemorrhoids, gout, rheumatism, parasites, Antitumor compounds skin disorders, burns, wounds etc.
2. <i>Citrullus</i> spp.	Urinary tract infections, poor blood circulation
3. <i>Cucumis</i> spp.	Sunstroke, stomach cancer
4. <i>Luffa</i> spp.	Purgative
5. <i>Trichosanthes</i> spp.	Cure dysentery, reduce fever, alleviate pain of swollen legs, purgative glycoside
6. <i>Cucurbita</i> spp.	Anticancer compounds, Urinary problem
7. <i>Benincasa hispida</i>	Laxative, diuretic, aphrodisiac. Cures urinary infections, biliousness, blood disease, tonic for heart, cooling, anthelmintic, dry cough, fever.
8. <i>Coccinia</i> spp.	Roots are used in the treatment of diabetes, sores and skin disease. Leaf decoction for bronchitis.
9. <i>Lagenaria</i> spp.	Leaves are diuretic, laxative

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GENETIC RESOURCES OF *Terminalia* : THEIR MAINTENANCE, EVALUATION, UTILIZATION AND CONSERVATION

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Studies on 130 accessions of *Terminalia* species complexes and their hybrids exhibited continuous variation. Maintenance of their genetic resources through *ex situ* conservation at various stations and their systematic characterization and evaluation and yield and quality trials have been discussed in detail. Strategies for effective utilization and conservation of germplasm and superior varieties of Pentaptera have also been earmarked.

Key words : *Terminalia arjuna*, *T. tomentosa*, genetic resources, maintenance, evaluation, utilization and conservation

Cultivation of *Terminalia arjuna* and *T. tomentosa* (section: Pentaptera) is the most important for tasar culture since economics of this agroforestry enterprise mainly depends on the total quality leaf produced in an unit area over an unit time. Of the three yield contributing factors viz., cultivating high yielding varieties, providing better agronomical practices and protecting crop from pests and diseases, usage of high yielding varieties is the cheapest and effective method. Lately, the need for a global plan of action for the conservation and sustainable utilization of forest genetic resources has been realized and *Terminalia* is not an exception to this.

Origin and distribution of *Terminalia*

Vavilov (1926) in his "Centre of Origin" hypothesis generalized that the genetic variability in populations is the greatest in the territory wherein the species arose and from where it subsequently spread elsewhere. Hence, Central India may be regarded as the centre of origin of section Pentaptera of genus *Terminalia*, despite of the fact that centre of origin of *Terminalia*

may be probably Malayasia since as many as 40 species have been reported from there. In addition, twenty seven species were reported from India whereas 11 species from tropical Africa (Srivastav *et al.* 1998). Accordingly, Indo-Malayan region may be regarded as the "ancestral home" of genus *Terminalia* from where it spread to all other biogeographical regions of the world. Conversely, all the 18 Australian species of *Terminalia*, appear to be endemic with the exception of *T. microptera* which occurs in Timor also. Hence, genus *Terminalia* probably differentiated independently in two or more regions and appears to have bitopic or polytopic rather than monotopic centres of origin. (Srivastav *et al.* 1997 a).

Genetic resources in Pentaptera

Due to predominant out-crossing, sexual recombination and segregation, mutations and natural selections, lot of inter as well as intraspecific variations occur in this genus which are sometimes so conspicuous that more than one species may be involved forming species complexes in *T. arjuna*, *T. tomentosa*, *T. bellerica*, *T. chebula* and

T. citrina. In section Pentaptera, according to Parkinson (1936), affinity and intergrading is evident among various varieties and forms of *T. arjuna* and *T. tomentosa* complexes. Hooker (1878) has described three varieties under *T. tomentosa* viz., *typica* (*alata*), *crenulata* and *coriacea*, while Roth, Wight and Arnot (quoted by Hooker, 1878), Gamble (1915, 1920), Blatter (1929), Parkinson (1936), Bahadur and Gaur (1980) and Srivastav *et al.* (1997 a, b) have treated them as distinct species. Likewise, *T. arjuna* var. *arjuna* and *T. arjuna* var. *angustifolia* described by Hooker (1978) have also been treated as distinct species as *T. glabra* W & A and *T. berryi* W & A respectively (Parkinson 1936, Srivastav *et al.* 1997 a, b). Besides, hybrids between entities from both the complexes have also been reported (Haines, 1922; Parker, 1920). On the basis of natural variation encountered, a total of twelve taxa and/or biotypes have easily been recognized in section Pentaptera viz., *T. berryi*, *T. glabra*, small leaf form and putative hybrids closer to *T. arjuna* in *T. arjuna* complex and *T. alata* var. *alata*, *T. alata* var. *nepalensis*, *T. crenulata* with big and small leaf forms, *T. coriacea* with small and big leaf forms and putative hybrids closer to *T. tomentosa* in *T. tomentosa* complex (Table 1).

Exhaustive explorations of genetic resources through plus tree selection (*ex situ* conservation) and observations recorded on 130 accessions of *T. arjuna* and *T. tomentosa* collected from tropical Central India (M.P., Orissa and Bihar) and their hybrid complexes have been found to exhibit continuous rather than discontinuous variations in fruit, foliar and stem/bark characteristics (Table 2). However, further explorations covering sub-tropical regions viz, Doon valley, Garhwal, Kumaon and Rohilkhand (Uttar Pradesh) and North-east India may be planned to collect valuable genotypes.

Maintenance of genetic resources

The maintenance of genetic resources is a

pre-requisite for conservation and evaluation and subsequent utilization for tasar culture. The major varieties of *Terminalia arjuna* are multiplied through air layering from common ancestors (ortets) and cultivated in RBD, each block consisting of 20-25 ramets for evaluation through bioassay studies in at least 180 × 180 cm or 120 × 180 cm spacing instead of 120 × 120 cm spacing for easy management. Besides, 10 ramets from each genotype/variety should separately be maintained as *ex situ* germplasm reservoir at 450 × 450 cm or 360 × 360 cm spacing and they should be allowed to grow freely without undertaking any rearing on them. Germplasm maintenance for *ex situ* conservation as well as for evaluation purposes may be resorted at each Regional Taser Research Station (RTRS) for indigenous as well as exotic biotypes as far as possible.

Ex situ field genebanks of Pentaptera species may be established at suitable localities viz., CTR & T.I., Ranchi, Tropical Forest Research Institute/State Forest Research Institute, Jabalpur; Kerala Forest Research Institute, Peechi; Institute of Forest Genetics and Tree Breeding, Coimbatore; Forest Research Institute, Dehradun and Botanical Survey of India, Shillong/R.T.R.S., Jorhat (Srivastav *et al.*, 1996). A consolidated *ex situ* germplasm bank of *Terminalia arjuna* and *T. tomentosa* like SMGS, Hosur may be established in due course of time at a suitable place, preferably in Central India through cloning those genotypes e.g., *T. arjuna* which respond favourably to air layering/cutting and through half sib seedlings (*T. tomentosa*) till clonal propagation technology is not developed for them.

Research on clonal propagation through cuttings/air-layerings and tissue culture may be intensified on priority basis in order to multiply and conserve true to type genotypes. Tissue culture technology may also be utilised for *in vitro* conservation as well as evaluation for salt resistance

Table 1. Distinguishing features of taxa in *Terminalia* (Section : Pentaptera)

Species	Taxa	Distinguishing features
1. <i>Terminalia arjuna</i> Bedd. (Species complex)	1. <i>T. berryi</i> W. & A. syn. <i>T. arjuna</i> var. <i>angustifolia</i>	Fruits comparatively very big 1-2 inches, bark smooth grey, flaking off in large thin layers. Wings of the fruit not very broad, their striation curving upwards. Leaves glabrous.
	2. <i>T. glabra</i> W. & A. syn. <i>T. arjuna</i> var. <i>arjuna</i>	Leaves narrow elongate-oblong suddenly narrowed into petiole with drooping branches L/B = > 4
	3. Small leaf form	Leaves often cordate
	4. Putative hybrids closer to <i>T. arjuna</i>	Leaves elliptic to lanceolate L/B = 3.0 - 3.5.
2. <i>Terminalia tomentosa</i> W. & A. (Species complex)		Bark grey, slightly rough, leaves broader than those of <i>T. glabra</i> and not perfectly smooth.
	1. <i>T. alata</i> syn. <i>T. tomentosa</i>	Bark rough, grey-black, not flaking in this layers. Wings very broad in fruits, striations of wings carried horizontally to the edge. Leaves tomentose rarely glabrous
	i). <i>T. alata</i> var. <i>alata</i> Heyne ex Roth syn. <i>T. tomentosa</i> var. <i>alata</i>	Leaves cordate or oblong suddenly narrowed into the petiole. Adult more or less hairy beneath, bark grey to black. Young ovary villous, fruits glabrous.
	ii). <i>T. alata</i> var. <i>nepalensis</i> (Haines) Fernandes <i>T. tomentosa</i> var. <i>nepalensis</i>	Leaves elliptic to oblong or ovate to oblong 5 × 8 cm., thinly wooly beneath, found in Central India
	2. <i>T. crenulata</i> Heyne ex Roth syn. <i>T. tomentosa</i> var. <i>crenulata</i>	Leaves oblong to elliptic or lanceolate, 13-30 × 4-10 cm, strongly tomentose beneath, distributed in northern India.
	a) Big leaf forms	Leaves narrowed into the petiole, obovate to elliptic, adult nearly glabrous beneath, young ovary and fruits glabrous, Common in Western Ghats.
	b) Small leaf forms	Obovate leaves
	c) Kahvi	Oblong leaves
3. <i>T. coriacea</i> (Roxb.) W & A. syn. <i>T. tomentosa</i> var. <i>coriacea</i>		Elliptic leaves
		Bark dark coloured like crocodile skin, leaves like <i>T. alata</i> but beneath with a close hard fulvous tomentum rather than villous.
		Fruits pubescent between wings. Common along Eastern Ghats.
	a) Big leaf forms	Obovate leaves
	b) Small leaf forms	Oblong leaves
4. Putative hybrids closer to <i>T. tomentosa</i>		Bark greyish black, rough and slightly cracked. Leaves bigger than those of <i>T. glabra</i> , nearly glabrous, veins protruding

genotypes in less space and for indefinite period. Attempts may be made to declare *Terminalia* species a national tree genus. Government of India may enforce laws to ban cutting etc. This will

facilitate *in situ* conservation and also protect the ecological balance (Srivastav *et al.*, 1996; Priya Ranjan *et al.*, 1994).

Evaluation of genetic resources

The conservation through maintenance and use of genetic resources are the two inseparable components of varietal improvement. Without systematic evaluation of existing genotypes, the available genepool in the germplasm collections can not be fully utilized to full extent. Objective oriented multidisciplinary efforts should be made involving three major steps viz. descriptive recording, systematic characterization and empirical testing.

(I) **Descriptive recording** : Descriptive recording is an essential step which provides the morphological details of each accession for cataloguing and classifying the material systematically. For descriptive recording, *Terminalia* (Pentaptera) descriptor is a must and the same has been prepared based on the observations on 130 accessions collected from Central India. The descriptor list is divided into nine major groups of characters pertaining to phytogeography, gross morphology, reproductive biology, anatomy, cytology, growth/yield attributes, quality parameters, responses to different cultivation practices and resistance to various pests and diseases (Srivastav *et al.* 1997, b). Format presented is similar to the one designed and approved by FAO and IPGRI for other crops and based on Mulberry descriptors (Dandin and Jolly, 1986) with certain modifications as applicable in case of *Terminalia* (Section: Pentaptera).

(II) **Systematic characterization** : The objectives of *Terminalia* (Pentaptera) breeding are production of more foliage of high palatability and nutritional value throughout the year, and with high ca-capacity of regeneration and amenable to vegetative propagation and genotypes with thick succulent leaves and high moisture content. Parameters contributing to above objectives in "Pentaptera" like mulberry may be as follows :

- a. Fast growth and high regenerating capacity
- b. Bushy nature i.e., production of maximum primary and secondary branches with short internodes.
- c. Thick succulent gummy leaves.
- d. Quick sprouting and high rooting capacity.
- e. Good response to agronomical practices like repeated pruning, manuring etc.
- f. High moisture content of leaves with better moisture retaining capacity.
- g. Better root initiation, growth and proliferation.
- h. Resistance to drought.
- i. Resistance to pest and diseases.

For better understanding of the extent of variability in each of the above characters and also to elucidate the relationship among them, a systematic preliminary characterization of all the collected accessions need to be done.

Yield trials and Quality evaluation

After assessment of all the individual characters contributing to growth and yield, the varieties/genotypes performing better can be taken for yield testing in RBD with three replications, each block clonally propagated as discussed earlier through air layering and uniform package of practices for manuring, pruning and leaf harvest may be adopted. While doing initial tests, material may also be multiplied for subsequent tests.

Quality of varieties can be tested both by bioassay and chemical analysis. Feeding trials can be conducted both by moulting as well as full rearing tests. In moulting test, observations on number of worms going for normal moulting, number of worms delayed to undergo moulting and coming out of the moult within the specific

Table 2. Species wise composition of *Terminalia* (Pentaptera) genotypes being studied at Central Tasar Research & Training Institute, Ranchi, India

Years of exploration	Taxa	No. of accessios	Location
1987	1. <i>T. glabra</i> syn. <i>T. arjuna</i> var. <i>arjuna</i>	12	Dhamtari, Jagadalpur (M.P.), Sundergarh, Nowrangpur (Orissa)
	2. Putative hybrids	10	Sundergarh, Nowrangpur (Orissa) and Jagadalpur (M.P.)
1989	1. Putative hybrids	2	Nowrangpur (Orissa)
1990	1. <i>T. glabra</i>	14	Ranchi (Bihar)
	2. <i>T. berryi</i> syn. <i>T. arjuna</i> var. <i>angustifolia</i>	2	Ranchi (Bihar)
	3. <i>T. alata</i> var. <i>alata</i> syn. <i>T. tomentosa</i> var. <i>alata</i>	8	Ranchi (Bihar)
	4. <i>T. coriacea</i> syn. <i>T. tomentosa</i> var. <i>coriacea</i>	3	Ranchi (Bihar)
	5. <i>T. crenulata</i> syn. <i>T. tomentosa</i> var. <i>crenulata</i>	1	Ranchi (Bihar)
	6. Putative hybrids	11	Ranchi (Bihar)
1993	1. <i>T. glabra</i>	18	Ranchi (Bihar), Balaghat, Bilaspur and Jagadalpur (M.P.)
	2. <i>T. berryi</i>	4	Ranchi (Bihar), Balaghat (M.P.)
	3. <i>T. alata</i> var. <i>alata</i>	2	Jagadalpur and Bilaspur (M.P.)
	4. <i>T. alata</i> var. <i>nepalensis</i>	2	Ranchi (Bihar)
	5. <i>T. coriacea</i>	1	Balaghat (M.P.)
	6. <i>T. crenulata</i>	22	Ranchi (Bihar, Bilaspur & Raigarh (M.P.)
	7. Putative hybrids	12	Ranchi (Bihar), Balaghat, Jagadalpur and Bilaspur (M.P.)

period must be observed. In this test, healthiness or otherwise of the worms reflects on the nutritive quality of the leaves which can be taken as an index. Hence, this test may be utilized for preliminary testing of large number of varieties at a time to assess the nutritional quality. In full rearing test, a constant number of worms may be kept. Their growth rate, and general healthiness are observed till fifth stage and ERR, SR per cent, filament length etc. should be recorded to correlate silk quantity to the nutritional quality of the leaf.

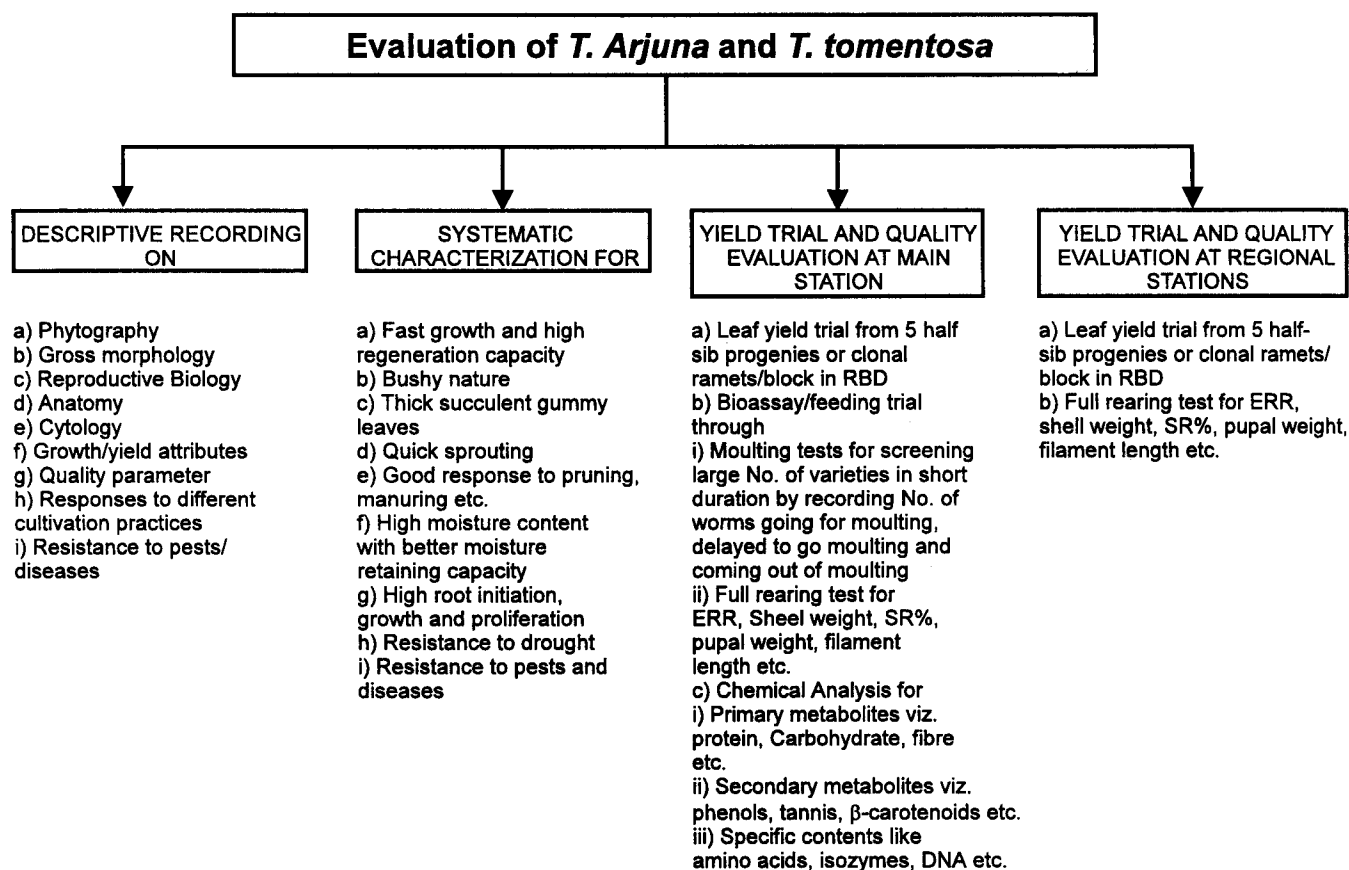
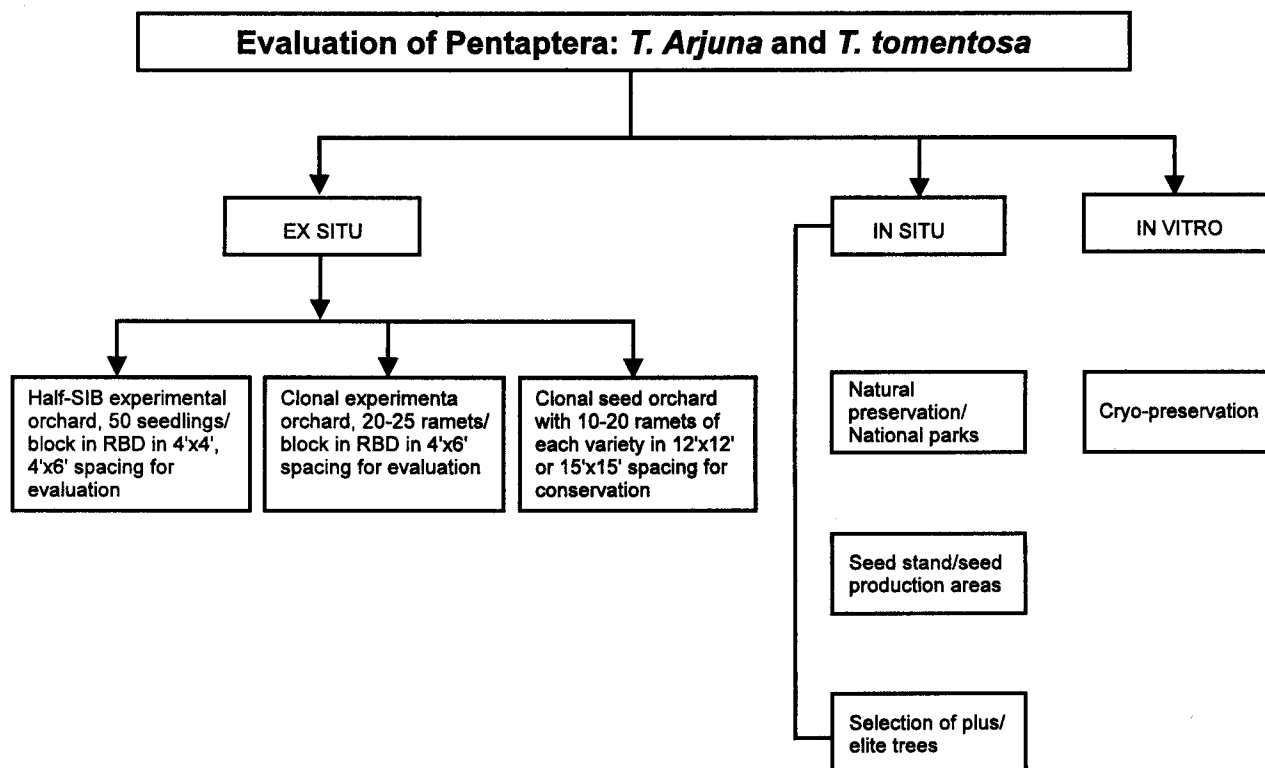
Besides, chemical analysis of leaves for primary as well as secondary metabolites may also be conducted. Analysis of specific contents like amino acids, isozymes, phenolics, β -sitosterol etc. may also be made to correlate with feeding trial results and also for establishment of phylogenetic

relationships of varieties/biotypes.

Consequently, various Regional Tasar Research Stations may also conduct similar yield and bioassay trials through full rearing and moulting tests for assessing suitability of various superior varieties to different agroclimatic conditions for recommending region/location specific varieties/biotypes following the same procedure alongwith local genotypes for at least three years. The superior ones performing well could be recommended later to the respective regions.

Utilization and conservation of genetic resources

For effective utilization of germplasm and superior varieties of Pentaptera intensive training to scientific personnels on characterisation, maintenance, documentation, evaluation and clonal

Fig. 1. Proposals for evaluation of *T. arjuna* and *T. tomentosa*Fig. 1. Proposals for maintenance of *T. arjuna* and *T. tomentosa*

propagation technology including tissue culture is urgently required. To achieve above goals, an All India Co-ordinated Project may be initiated under Non-mulberry Silkworm and Plant Germplasm Station which may be established somewhere with units at various places for different non-mulberry food plants. Following strategies may be adopted for utilization and conservation of genetic resources of Pentaptera :

1. Explorations covering subtropical regions viz., Doon valley, Garhwal, Kumaon, Rohilkand and North-east India and tropical regions of South India should also be conducted.

2. Preliminary systematic characterization of all known varieties/accessions of Pentaptera should be done

3. Greater emphasis should be laid on under utilized and endangered varieties/genotypes like Kahvi from Bilaspur, Ulta Saja from Amarkantak (Madhya Pradesh) and spontaneous hybrids from Central India as local varieties.

4. Small and big leaf forms of *T. crenulata* and *T. coriacea* may be introduced from Western/eastern Ghats to Central India for various afforestation schemes.

5. A consolidated *ex situ* germplasm bank of Pentaptera should be established through cloning/half sib seedlings in Central India.

6. Research on clonal propagation and tissue culture should be intensified for breeding and utilization of true to type genotypes.

7. Collaboration with Indian Council for Forest Research and Education (ICFRE) institutions, state forest depts. and NGOs should be established/increased.

8. Collaboration between different RTRs should be enhanced for exchange of germplasm.

9. Genus *Terminalia* should be declared as

a National Tree genus to protect environment and encourage tasar culture.

10. Potentialities of *T. arjuna* for reclamation of alkaline/saline soils, water-logged/peaty soils and ash dykes from thermal plants and *T. tomentosa* for reclamation of barren rocky lands should be publicised for inclusion under social forestry programmes by Railways, SECL, CCL, WCL, NTPC private industries and NGOs.

11. Religious sanctity of Arjuna of Mahabharata period may be publicised among rural populace to check cutting.

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COLLECTION OF CASTOR (*Ricinus communis* L.) AND SAFFLOWER (*Carthamus* spp.) GERMPLASM IN NORTH-WESTERN HIMALAYAS AND TRANS-GANGETIC PLAINS OF INDIA

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In a crop specific exploration to collect diversity in castor (*Ricinus communis* L.) and safflower (*Carthamus tictorius* L.) and its wild relatives from north-western Himalayan region and trans-gangetic plains of India (in collaboration with Directorate of Oilseeds Research, Hyderabad, Andhra Pradesh and Project Coordinating Unit-Safflower, Solapur, Maharashtra), a total of 226 accessions representing diversity mainly in wild forms of castor (134), safflower (7) and wild safflower (56) were collected. The important variability in castor included instant shattering and forceful seed ejecting types exhibiting primitiveness, small shining heavy seeds indicating high oil contents and resistance to biotic stresses, non-spiny and non-shattering types and red rose foliage types. The variability in safflower included cold tolerant types exhibiting more similarity to *C. lanatus* L. from Hamirpur and Kangra district (Himachal Pradesh), extreme heat and drought resistant types in *Carthamus oxycantha* Bieb., cold and drought resistant types in *Carthamus lanatus* L from Phulwama and Baramulla district in Jammu & Kashmir. The lower hills and submontane areas in Himalayan region were observed to be the storehouse for highly variable primitive forms of castor, distributed in truly wild state. The drier areas in Gurgaon, Mahendragarh and Bhiwani district of Haryana; Bhathinda, Barnala and Firozpur district of Punjab and adjoining pockets in Kathua district of Jammu & Kashmir were found to be the hot spots of variability in *Carthamus oxycantha* Bieb. and the niches around Chandhara village in Phulwama District and Singhpora village in Baramulla District of Jammu and Kashmir State for *Carthamus lanatus* L. The ethno-botanical studies on the targeted species revealed that the local people, particularly the ethnic groups in the remote areas of northwestern Himalayan region, are heavily dependent on these plants to meet their medical requirements effectively.

Key words : Exploration, collection, castor, safflower, north-western Himalayas, trans-gangetic plains

Castor and safflower are very important oilseed crops of India having a lot of diversity particularly in wild and cultivated forms. The diversity in castor and safflower from north western Himalayan region and trans-gangetic plains is represented neither in the base collection at National Gene Bank at National Bureau of Plant Genetic Resources, New Delhi nor in active collections at the Directorate of Oilseeds Research (DOR), Hyderabad and Project Coordinating

Unit, Solapur, Maharashtra State. Considering this gap and also the recommendations of Germplasm Advisory Committee on Oilseeds, four north Indian States i.e. Jammu & Kashmir, Himachal Pradesh representing north-western Himalayan region, Haryana and Punjab representing trans-gangetic plains were surveyed. The surveyed areas lie between 73°8' to 78°8' East longitude and 27°7' to 34°5' North latitude with an

altitudinal range of 170 to 3000 m above mean sea level. The soils in this regions are mostly sandy, sandy loam, loam, clay, silt loam and silt, stony, gravelly and rocky with black, yellow, red and brown colour exhibiting wide variations in fertility levels from very poor to highly fertile.

METHODOLOGY

A circular route with coarse grid method of sampling at 10-15 km intervals was followed and occasionally super-imposed by fine grids so as to capture maximum variability (Jain, 1975 and Hawkes, 1976), particularly in the areas of the high concentration of diversity. A few to 400 mature capsules/heads/seeds, as per availability, were collected following random as well as biased sampling to collect specific genotypes (Sinha, 1981), using hand gloves and secateurs. The distinct morpho-types occurring simultaneously in the same population were sampled separately wherever possible. The passport data were recorded for each accession. The enroute diversity in other crops and wild relatives was also collected. The observations on 100 seed weight, length, breadth of seed and other post harvest characters were recorded in the laboratory. Ten old traditional farmers/donors were interviewed for ethno-botanical information.

DIVERSITY COLLECTED

A total of 226 collections representing diversity in castor (134) and safflower (7), wild safflower (56) in the targeted species and others (27) was collected (Table-1) from 124 sites in extremely diverse habitats ranging from the parched sand dunes in the Thar desert to hilly dissect in high Himalayas. The diversity in other crops was represented by four samples of local landraces of maize, two samples of paddy, four samples of wild *Solanums*, *Saccharum*, pumpkin, and medicinal plants like ashwagandha etc. The important variability in the targeted species is discussed.

Safflower (*Carthamus tinctorius* L.)

Safflower is an erect annual herb with spinosely serrate leaves and globular flower heads. The plant is found only under cultivation and is supposed to have originated either from *C. lanatus* Linn. or *C. oxycantha* Bieb in two primary centres of origin, viz. the mountainous region of Abyssinia and Afghanistan (Kupzow, 1932). Being highly resistant to drought; it is mostly cultivated as an oilseed crop in sandy soils with poor fertility in rainfed areas, generally mixed with wheat, barley, chickpea, mustard etc. Occasionally safflower is also grown for dye purpose. It is vernacularly known as 'kusum' in Haryana and 'kusumbha' in Himachal Pradesh and Kashmir. It is used as a leafy vegetable at tender stage. The survey of literature indicated the distribution of three species of *Carthamus* i.e. *Carthamus tinctorius* Linn., the cultivated safflower and two wild species i.e. *C. oxycantha* Bieb. and *C. lanatus* L. in the targeted region. The information gathered from the folk revealed that some time 20-40 years ago, in some pockets of Hamirpur, Kangra, Una, Solan and Sirmour districts of Himachal Pradesh and Kathua district in Jammu & Kashmir State, the traditional farmers used to grow safflower landraces for personal/domestic/religious/medicinal purposes on small scale in small plots, in home steads, temple compounds and kitchen gardens. The inter culture of safflower with wheat, chickpea and other *rabi* crops was also quite common at that time. But the practice of growing safflower diminished continuously with the passage of time and the old people who used to prefer it. The diminishing of diversity was so severe that in the current exploration, out of the four states surveyed, only seven samples of *C. tinctorius* could be collected from five villages in Hamirpur and Kangra districts of Himachal Pradesh. These populations of *C. tinctorius* L. exhibited more similarity to *C. lanatus* than *C. oxycantha* in morphological characters and general appearance. A narrow range of variability

was recorded for observable traits in the sampled

Table 1. State/District wise collections of castor and safflower from Northwest Himalayas and trans-gangetic plains of India

Diversity Collected/Number of collections			
State/District	Castor (<i>Ricinus communis</i>)	Wild Safflower (<i>Carthamus tinctorius oxyacantha</i>)	Safflower (<i>Carthamus</i>)
Haryana	26	31	-
Faridabad	-	7	-
Gurgaon	-	1	-
Mahendragarh	4	4	-
Bhiwani	2	3	-
Hisar	2	4	-
Sirsa	5	7	-
Ambala	3	-	-
Kurukshetra	2	-	-
Kaithal	3	3	-
Karnal	5	-	-
Sonapat	-	2	-
Punjab	34	20	-
Bathinda	1	3	-
Ludhiana	3	1	-
Gurdaspur	4	1	-
Amritsar	4	2	-
Pathankot	2	-	-
Hoshiarpur	10	-	-
Sangrur	4	2	-
Barnala	1	3	-
Firozpur	4	8	-
Patiala	1	-	-
Himachal Pradesh	55	-	7
Una	2	-	-
Solan	7	-	-
Shimla	5	-	-
Bilaspur	9	-	-
Hamirpur	3	-	4
Kangra	9	-	3
Mandi	8	-	-
Chamba	2	-	-
Kullu	3	-	-
Kinnaur	2	-	-
Sirmour	5	-	-
Jammu & Kashmir	19	5	-
Jammu	9	5	-
Doda	4	-	-
Rajauri	5	-	-
Kathua	1	-	-

Total	134	56	7
Opportunistic collections			29
Total Diversity			226

populations. The samples represented variability in sparsely spiny types, orange flower colour, medium sized capitulum/seeds with white colour, plant height (25 to 78 cm), primary branches (2 to 8) mostly on 2/3 upper portion of the plant.

Wild safflower (*Carthamus oxyacantha* Bieb.)

Fifty six natural populations of *C. oxyacantha* were sampled. It is vernacularly known as 'kantiali' in Haryana and 'poli' in Punjab and adjoining parts in Jammu and Himachal Pradesh. It is a medium sized (20 to 85 cm), bushy and thorny herb, growing wild in the arid tract of the surveyed areas. It is a trouble some weed found abundantly in the harvested fields of wheat, gram, lentil, mustard and other *rabi* crops. *C. oxyacantha* exhibited high concentration of diversity in drier parts in Gurgaon, Mahendragarh, Bhiwani, Hisar and Sirsa districts of Haryana; Bathinda, Patiala, Sangrur, Barnala and Firozpur districts of Punjab; Kathua district of Jammu & Kashmir and Una district of Himachal Pradesh. In the areas of abundance, poor people use its oil for illumination and edible purpose. The seeds are collected and parched and eaten as such or mixed with wheat or gram. The plant is said to be good fodder at tender stage but the mature plant is hardly touched, unless the spines are broken by beating with sticks. The samples exhibited variability in plant height (20-85 cm), branching habit (basal/top branching and intermediate types), capitulum size, (small to medium), seed colour (white, gray, mottled gray, black and brown with and without blotches), seed size, spininess (sparse to dense).

Carthamus lanatus L.

It is found in Kashmir and Himachal Pradesh from 1500 to 1800 m. above mean sea level and locally known 'kant' or 'kand'. A thorough search was made during the exploration. A few colonies

of *C. lanatus* could be identified as weed in saffron (*Crocus sativus* L.) fields in Chandhara village in Phulwama district, located 20 km away from Srinagar on Jammu- Srinagar high way. Some colonies also existed in apple orchards around Singhpora village, 5 km from Sopore town in Baramulla district. The plants in all the colonies were at flowering stage and hence collections of seed could not be possible. However the sites where these colonies existed, were shown to the Scientists of Sher-e-Kashmir University of Agril. Sci. & Tech. Srinagar, for the purpose of their collection at the time of seed maturity, probably in the middle of August.

Castor (*Ricinus communis* L.)

Castor is an important oilseed crop of India, cultivated for seeds which yield a fast drying, non-yellowing oil used mainly in industry and medicines. The castor is believed to be a native of tropical Africa. India is considered as a secondary centre of diversity/origin of castor and Indo-gangetic plains are the centre of Botanical variability (Stuhlmann, 1909; Kulkarni and Ramamurthy, 1977; Moskin, 1986; Anjani et al, 1993 and Duhoon et al, 1996). Through its occurrence in scrubby jungles of the outer Himalayas in a truly wild state, together with the antiquity of its use as drug in Sanskrit literature are held to a point to its being the native of India as well of Africa. Castor oil has great industrial and medicinal value. The species is common throughout the country in all climates ranging from tropical, subtropical to temperate, with high concentration of diversity in the drier parts with tropical climate. 'Errand' and 'arandi' are the local/vernacular names of castor in this region.

The castor, in the surveyed region, grows as natural wild or as escape near road/river-sides, back/court yards, temple compounds, wastelands and most preferably on garbages around the village. The organized cultivation of castor as a main

crop is not seen in the targeted areas. Occasionally the castor is grown as guard/fence rows to protect the main crop from men/animals. The early types mature in May/June, whereas the late types mature in June/July. The plants, if not uprooted or cut, become perennial and gradually grow into trees up to 7-8 m height. Nevertheless, good extent of variability occurred in the targeted areas. One hundred thirty four populations or individual plant samples representing local diversity in castor were collected from 125 sites in diverse habitats ranging from road/river sides, courtyards/backyards and waste lands/garbage's around villages, farmers fields. The collected samples represented diversity from an altitudinal range of 170 to 1600m above mean sea level. Out of 134, 54 samples represented diversity from Himachal Pradesh and 19 from Jammu & Kashmir and thus collectively these 73 samples represented diversity from northwestern Himalayan region. Whereas 34 samples collected from Punjab and 22 samples from Haryana summing up to 56 combinedly represented diversity from trans- gangetic plains. At the district level, the maximum number of 9 samples each collected from Kangra and Bilaspur in H.P.; Jammu in J & K and Hoshiarpur district in Punjab. Besides, a good extent of diversity was recorded in Solan, Mandi, Rajauri and Sangrur district. The spiny and shattering types were more frequent than non-spiny and non-shattering types throughout the regions surveyed. However the non-spiny and non-shattering types were endemic in their distribution with high frequency from Ramdas village to Attari border Check Post in Amritsar district near Indo-Pakistan border. The primitive types showing instant shattering with forceful cracking of capsules and ejecting the seeds, were concentrated in submontane areas and lower hills around Pathankot and Jammu. The castor collections exhibited variation in seed colour (gray, brownish white, brown, red and black with and without mottling), seed size (small, medium to bold), seed shape (elongated, square, oblong

and triangular), appearance (shining and dull), plant/spike colour (green, sun-red and golden), spike (short/long and compact/loose), spike length (10 to 75 cm), leaf size (small/large), leaf lobing (deep/shallow), growth habit (fast growing, tall types and slow growing), shattering and non shattering types and early and late maturing types. The extent of variability in 100 seed weight was very high varying from as low as 6.3 g. (Accession SKY-11) to as high as 19.0 g (Accs. SKY-59). Seed length varied from 0.62 cm (SKY-15 and SKY-94) to 12.5 cm (SKY-102), Seed breadth exhibited variation from 0.47 cm (SKY-1) to 1.07 cm (SKY-48).

ETHNOBOTANICAL USES

The information on indigenous knowledge and the various ethnobotanical uses of *Carthamus* species and castor were collected from the local farmers through personal interviews. It was observed that all the arial parts of the plant are used for various purposes as listed below.

(a) Safflower (*Carthamus tinctorius* L.)

- The petals are used as a substitute of saffron and also as edible due to colour rice and other foods. The dried petals are also used to adulterate saffron.

- Dried petals are soaked in water and this water is used as a substitute of holy Ganga water in all the rituals from birth, marriage to death by the Hindus in Hamirpur, Kangra, and Unna district of Himachal Pradesh.

- Tender shoots of safflower are used as leafy vegetable and are very rich in proteins and vitamins.

- The flowers are used as stimulant, sedative and emmenagogue.

- The charred oil is used for healing sores and the massage effectively controls rheumatism.

- Safflower is grown continuously for 12

years by a family to worship God for blessings and to come out of the evil star effects.

- Equal amount of dried petals of safflower, tea and zinger are boiled in water or milk and sugar is added to the taste. This preparation is taken regularly to effectively control the rheumatism and spondulitis. Alternatively the decoction of dried petals is also used by the locals to treat rheumatism and the joints pain.

- The mature seeds are soaked in water and grinded to form a paste. The paste is cooked in milk and sugar is added to taste. This preparation, locally called as 'kheer', is aphrodisiac in nature and given to improve the vigour and sexual potential of males.

(b) Wild safflower (*Carthamus oxycantha* Biet.)

- The powder of the dried petals mixed with honey s given to cure cough and cold by the locals in the drier parts of Haryana.

- The plant at the flowering stage is chopped in to pieces and the equal amount of chopped Dhuwansa plant are boiled in water. The boiling is done till 1/3 of water remains and crystal sugar (*Mishry*) is added to it. This decoction is given for the treatment of sunstroke or related headache or migraine.

- The paste of the crushed seed is applied for ripening of tumor particularly developed due to hair uprooting.

- Decoction of the petals is given to control joint pain or arthritis in the Kathua district by Kashmiries.

- The castor seed and castor oil are very common ingredients of Indian folk medicines, particularly for the treatment of arthritis, asthma, boils, burns, cold, colic, constipation, dermatitis, fever, flu, headache, rhemuatism and skin scores.

- The green leaves of castor, coated with mustard oil, are mildly heated and bandaged to cure muscular/joint pains.

- The paste of crushed castor seed is applied externally for the treatment of ulcers.

- Castor oil is used in massage by the local women to make their skin smooth, tight and more beautiful.

- Castor oil is used with sweet and hot milk as a purgative to cure intestinal disorders.

- The massage of castor oil and garlic is used by the locals for the treatment of rheumatism and arthritis.

- The external application of the paste of crushed castor seed or castor oil mixed with sulphur powder acts as counter irritant in scorpion sting and skin scores.

OPPORTUNISTIC COLLECTIONS

The enroute interesting diversity in non-targeted species was also collected. Twenty nine samples included the land races of maize (sweet and tasty type with bold yellow grains and cobs); 'kashiatsu' a land race of rice with high nutritional value, especially eaten by the ladies at the time of delivery; awnless wheat, wild species of *Solanum*, *Hordium*, *Avena*, *Nicotiana*, *Mlilotus*, *Saccharum* and medicinal plants like *Citrulus*, *Abrus*, *Aswagandha* (*Withania somanifera*), *Chakshu*, *Khoob kalla*, *Haloshena*, *Bahng jira* etc. used by the local people inhabiting the explored areas.

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CHARACTERIZATION OF MANGO GERMPLASM IN NORTH KARNATAKA, INDIA: 1. TREE MORPHO-PHENOLOGY, PRODUCTIVITY AND FRUIT CHARACTERS

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A study was conducted on characterization of mango germplasm with 67 genotypes, on trees of 17-19 years old, maintained at the College of Agriculture, Dharwad, India. The genetic variability was observed for 40 characters, comprising tree morpho-phenology and fruit physico-chemical and quality characters. High phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) were obtained for hermaphrodite flowers, panicle number, fruit number, tree volume, bearing panicles at harvest stage, pulp content per fruit, sugar, titratable acidity and ascorbic acid contents. High heritability along with high expected genetic gain was noticed for tree volume, panicle number, bearing panicle number, total and hermaphrodite flowers per panicle, fruit number, fruit volume and pulp content, which suggested that improvement in these could be brought by direct selection. High positive correlations were recorded for fruit volume with fruit weight (0.997), pulp weight with minor width (0.875), physiological loss of fruit weight with major width (0.804), leaf area with leaf breadth (0.911), fruit number with bearing panicles (0.892), but a high negative correlation recorded between earliness of panicle emergence and duration of flowering (-0.647). Significant negative correlations were also noticed between fruit number and fruit size (-0.38) and fruit number and sugar content (-0.33). Grouping of accessions based on tree size, bearing capacity, irregularity level, fruit size and shape have been presented in tabular forms, that enable to locate genotypes for desirable traits.

Key words: *Mangifera indica*, flowering, shoot and panicle characters, fruit characters, tree size, yield, irregularity index, genetic variability

Mango is a predominant fruit crop of the transitional belt of Karnataka and also in India. Properly described, characterized and evaluated germplasm is a necessity for its improvement. One of the main objectives of the mango improvement in India and also elsewhere is to develop dwarf tree types with good fruiting potential (Iyer, 1991). Fruit characters, however relied most extensively for the descriptions and classification of mango varieties by many fruit taxonomists (Woodhouse, 1909; Rolphs, 1915;

Wester, 1920; Singh and Singh, 1956 and Gangolly *et al.*, 1957). In most cases the prolific bearers are known to be lacking in quality and those with good fruit quality are either irregular or shy bearers (Singh, 1990). Success in mango improvement primarily depends on the nature and magnitude of variation present in the germplasm. An assesment of heritable and non-heritable components in the total variability will be of immense value in the choice of selection procedures through breeding. Characterization

based on certain qualitative characters is useful in the identification of genotypes, as these attributes are more reliable over environments. Hence the present study aims to estimate the amount of genetic variability, heritability and expected genetic advance for tree morpho-phenology, fruit physico-chemical characters and also in certain qualitative characters.

MATERIAL AND METHODS

Sixty seven mango accessions (see Table 1) were planted during July 1975 at the Silver Jubilee Orchards of the College of Agriculture, Dharwad, Karnataka, in a randomized block with 4 trees each per replication and experiment consisted of two replications. Among these, 63 accessions were obtained from the Regional Fruit Research Station, Vengurla, Maharashtra and 4 accessions of local origin collected from the orchards around Dharwad and North Kannada districts. Brief descriptions of most of these accessions may be found in the International Checklist of Mango Cultivars (Pandey, 1984). All the cultivars were grafted on an unknown polyembryonic rootstock. The present study is based in the data obtained from trees for 2 successive seasons in 1992-93 and 1993-94 during their 17-19 years of orchard life. Two trees were selected for each replication for recording of observations and the mean data for the 2 years is presented for 40 characters, as shown in the Table 2(a and b).

The data were subjected to the standard statistical procedures of analysis of variance (ANOVA). The phenotypic and genotypic coefficients of variation (PCV, GCV) were computed as suggested by Burton and Dewane (1953). Heritability in broad sense was based on the formula of Lush (1940) and the expected genetic advance (GA) derived as per cent mean following Johnson *et al.* (1955).

Table 1. Accessions of mango germplasm at the College of Agriculture, Dharwad (Karnataka, India)

A C C E S S I O N S		
Alampur Baneshan (alb)	Alphonso (alp)	AuRumani (aur),
Beneshan (ben)	Bombay Green (bg)	Baramasi (bms)
Bappekai (bpk)	Batlimavu (btl)	Chandramavu (chm)
Chausa (chs)	Cowasji Patel (cjp)	Cherukurasam (ckr)
ckr × Khader-18/16 (ckr.kdr)	Creeping (crp)	Suvarnaksha (csr)
csr × nl (csr.nl)	Dashehari (dhr)	Dilpasand (dlp)
Dophasla (dps)	Fernandin (fnd)	Fazli (fzl)
Himayuddin (him)	Jehangir (jeh)	kari Ishad (kid)
Kurukkan (kkn)	KO-11 (ko-11)	KO-27 (ko-27)
Kalepad (kpd)	Langra (lgr)	Local-15L (loc-1)
Local-36L (loc-2)	Local-98L (loc-3)	Local-4 (loc-4)
Lal Pairi (lpr)	Lucknow Suffaida (ls)	Mulgoa (mlg)
Mallika (mlk)	Nekkare-1 (nek-1)	Nekkare-2 (nek-2)
Neelum (nl)	Neeluddin (nld)	Neelgoa (nlg)
Neeleshan (nls)	nl × alb-92 (nl.alb-92)	nl × alb-94 (nl.alb-94)
nl × alb-137 (nl.alb-137)	nl × him-32 (nl.him-32)	nl × him-33 (nl.him-33)
nl × him-46 (nl.him-46)	nl × him-63 (nl.him-63)	nl × him 3/7 (nl.him-3/7)
nl × Panchadarakalasa-4 (nl.pk-4)	nl × pk-77 (nl.pk-77)	nl × pk-78 (nl.pk-78)
Nazuk Pasand (nzp)	Olour (olr)	Peddarasam (pdr)
Pahunan (pht)	Pulihora (plh)	pairi (pr)
Rumani (rmn)	Rataul (rtl)	Ratna (rtn)
Sardar (sdr)	Swarna Jehangir (sj)	Totapuri (tp)
Vellaikolamban (vlk)		

Table 2(a). Description of 21 tree morpho-phenological and productivity characters

S. No.	Character	Unit	Method of estimation
1.	Tree volume (Tv): (Castle,1983)	m ³	$Tv = 1/6 \pi \times h \times 2r^2$, where, h-height of the tree(m) and r-canopy radius(m) i.e., r = canopy spread (East-West + North-South)
2.	Bearing Shoot Length (Lsh):	cm	Ten tagged shoots with active terminal buds were measured for each tree during mid-October of 1992 and 1993
3.	Proximal shoot length (Lpsh):	cm	Proximal shoots in all the above cases,measured
4.	Number of leaves (Lvs):	number	Active leaves present on the above shoots
5.	Leaf length (Lln):	cm	Average of leaves from 3rd and 4th positions from tip of the above shoots
6.	Maximum leaf width (Lbr):	cm	As above
7.	Leaf area (Lar):	cm ²	Derived by using a planimeter
8.	Panicle emergence (Pem):	rating	Based on time of emergence on the above shoots as: very early (before 15 D3cember)-1, early (15-30 December)-2, normal (1-15 January)-3, late (16-31 january)-4 and very late (beyond 31 January)-5
9.	Panicle length (Lpa):	cm	Length of primary rachis/rachii at peak flowering
10.	Thickness of primary rachis (Tpa):	mm	Measured at the base of primary rachis/rachii by Vernier caliperse
11.	Colour of the primary rachis (Pcol):	rating	With reference to Exotica colour chart as: green-1, sea-foam colour/creamish white-2, pink/red tinge on green background-3, light pink/red/maroon-4 and deep red/purple-5
12.	Secondary rachii per panicle (Rac):	number	Recorded from the base of the primary rachis to its tip
13.	Hermaphrodite flowers (Hfl):	number	Counted at peak flowering and just after
14.	Total flowers (Tfl):	number	Male flowers and Hfl, together
15.	Flowring duration (Dfl):	days	From the date of first flower opening to the date of last flower opening per panicle
16.	Panicles per tree (Pan):	number	Counted by marking in each of the 4 directions in a tree at the time of peak flowering
17.	initial fruitset (Ifs):	number	Fruitlets per panicle set at marble stage
18.	Bearing panicles (Bpn):	number	Panicles per tree that carried atleast one fruit till harvest maturity
19.	Fruit retention (Frt):	number	Fruits per panicle at harvest
20.	Fruit yield (Frn):	number	Fruits per tree at harvest
21.	Irregularity index (Ir):	per cent	As suggested by Pearce and Dobersek-Urbane (1967)

Table 2(b). Description of 19 fruit characters* studied in mango

Sl. No	Character	Unit	Method of estimation
22.	Fruit volume (Frv)	cm ³	Volume of fleshly harvested fruits estimated by water displacement
23.	Fruit weight (Frw)	g	Mean weight of the above fruits
24.	Fruit length (Frl)	cm	Length from base to apex, measured by Vernier caliper
25.	Major fruit-width (Fb1)	cm	Maximum width along dorsal-ventral direction
26.	Minor fruit-width (Fb2)	cm	Maximum width between left and right shoulders
27.	Ripe fruit weight (Rfw)	g	Fresh fruit individually wrapped under newsprint paper and kept for ripening in ventilated cartons. Just ripened fruits were weighed as marked by colour break and slight softening of the fruit mass.
28.	Physiological loss of weight (Plw)	g	Plw - Frw - Rfw
29.	Pulp weight (Ppw)	g	Pulp/juice extracted from ripened fruits
30.	Stone weight (Stw)	g	Weight taken direct soon after pulp/juice extraction
31.	Total soluble solids (Tss)	per cent	Pooled pulp/juice samples taken in duplicate were recorded by Erma hand refractometer
32.	Reducing sugars (Rs):	g/fruit	Estimated as per A.O.A.C. (1970)
33.	Total sugars (Ts)	g/fruit	Cumulative of non-reducing and reducing sugars
34.	Titrateable acidity (Tac)	g/fruit	By titrimetry, using phenolphthalein and standard sodium hydroxide
35.	Ascorbic acid content (Asc)	mg/fruit	Following the procedure of A.V.C., (1966)
36.	Pulp fubreness (Fbr)	rating	Average of 5 judges rated as: negligible-1, slight-2, moderate-3, rich-4 and heavy-5
37.	Ripe fruit firmness (Fir):	rating	As above and rated as: infirm-1, moderate firm-2 and very firm-3
38.	Juiciness of the pulp (Jui):	rating	As above and rated as: less juicy-1, medium-2 and very juicy-3
39.	Ripe fruit skin colour (skc)	rating	As above and rated as: greenish/unchanged ground colour-1, light greenish yellow/slight change-2, medium yellow/cadmium-3, deep chrome/yellow/orange-4, slight red bluish on any background colour-5 and deep red blush on any background colour-6.
40.	Pulp colour (Ppc)	rating	As above and rated as: light yellow/whitish-1, medium yellow/light orange-2 and deep orange-3.

*mean of 8 fruits/replication

RESULTS AND DISCUSSION

Variability estimates such as range, phenotypic and genotypic coefficients of variability, heritability and expected genetic advance are presented in Table 3 for both tree morpho-phenology and fruit characters. The F test of ANOVA indicated that all the studied characters were highly significant.

High PCV and GCV were noticed for the morphological characters; hermaphrodite flowers (70.3-62.7), panicles per tree (56.0-51.0), fruit yield (62.8-55.9), tree volume (58.0-57.2) followed by initial fruit set and bearing panicles and among the fruit characters titratable acidity (93.0-89.1), ascorbic acid content (79.0-75.7) followed by reducing sugars, pulp weight, total sugars and physiological loss of weight. These attributes indicate that a greater variability already existed among the entries, suggesting ample scope for improvement in such characters. Moderate PCV and GCV were recorded for fruit retention, total flowers, proximal shoot length, colour of the primary rachis, bearing shoot length and leaf area among the morphological characters and for ripe fruit weight, fruit weight, pulp fibre content, stone weight and ripe fruit skin colour among the fruit characters. Whereas low variability was noticed for leaf length, secondary rachis per panicle, number of leaves, maximum leaf width, thickness of primary rachis, flowering duration, panicle emergence, panicle length, fruit length, major fruit-width, minor fruit-width, total soluble solids, ripe fruit firmness, juiciness of the pulp and pulp colour. This emphasizes the need for generating more variability for these characters.

High heritability and high expected genetic gain was noticed among the morphological characters, such as total flowers (0.704-949.2), panicles per tree (0.831-417.2), fruit yield (0.79-220.4), bearing panicles (0.812-147.1), hermaphrodite flowers (0.794-113.8) and tree volume (0.973-60.8) and among the fruit

characters for fruit volume (0.985-309.5), fruit weight (0.982-304.0), ripe fruit weight (0.981-278.3) and pulp weight (0.972-207.1). This indicates a definite scope for improvement in these characters, though selection is to be made in a mixed population but can also be extended for a correlated progress in the monoculture (Spitters, 1984) and may support the competitive ability to progress by concentrating on to a fewer individuals (Cannell, 1984). High heritability with low expected genetic gain was recorded for shoot length, proximal shoot length, number of leaves per shoot, leaf length, maximum leaf width, panicle length, thickness of primary rachis, secondary rachis per panicle, colour of primary rachis, panicle emergence, initial fruit set, fruit retention, fruit length, major fruit width, minor fruit-width, total soluble solids, reducing sugars, titratable acidity, ascorbic acid content, pulp fibre content, ripe fruit firmness, juiciness of the pulp, ripe fruit skin colour and pulp colour. These results suggest that though they were environmentally stable, due to non-additive gene effects, the direct selection based on these characters would be less effective, hence should be resorted to indirect selections.

Correlation study among these characters indicated very high positive correlations for leaf area with maximum leaf width (0.911), leaf area with leaf length (0.839), the morphological characters fruit yield with bearing panicles (0.892) and shoot length with proximal shoot length (0.658), whereas high negative correlation was recorded for duration of flowering with panicle emergence (-0.647). Similarly among the fruit characters, very high positive correlations were recorded for fruit weight with fruit volume (0.997), ripe fruit width with fruit volume (0.996), physiological loss of weight with major fruit-width (0.804), pulp weight with minor fruit width (0.722) and total sugars with reducing sugars (0.712). Hence any manipulation in these characters would also involve their counterpart.

Table 3. Estimates of genotypic variability, heritability and genetic advance in mango

Sl. No.	Character	Range	Mean	PCV %	GCV %	Heritability (H ²)	Expected GA % of Mean	F value
a. Tree morpho-phenology								
1.	Tv	7.6 (kkn)-115.5 (tp)	52.2	58.0	57.2	0.973	60.7	74.02**
2.	Lsh	5.1(rmn) - 20.5 (nl.him-32)	10.7	31.2	26.5	0.715	4.9	6.03**
3.	Lpsh	5.0 (mlg)-16.8 (nl.him-32)	8.6	38.5	30.5	0.629	4.3	4.39**
4.	Lvs	8.0 (nl.pk-4) - 17.2 (nl.pk-77)	12.6	18.2	15.2	0.700	3.3	5.67**
5.	Lln	13.4(mlg) - 24.5(alp)	17.8	15.2	12.4	0.668	3.7	5.01**
6.	Lbr	2.9(nzp)-7.6 (vlk)	4.7	20.7	18.4	0.791	1.6	8.57**
7.	Lar	29.2(nzp)-109.5 (vlk)	61.8	32.4	26.7	0.680	28.0	5.26**
8.	Pan	72(nek-1)-1445 (kpd)	435.3	56.0	51.0	0.831	417.2	10.84**
9.	Bpn	30.5(ko-11)-403.5 (kpd)	165.2	53.2	48.0	0.812	147.1	9.63**
10.	Lpa	9.0(kkn)-39.4 (vlk)	26.7	21.3	18.5	0.753	8.8	7.09**
11.	Tpa	3.8(nlg)-8.9 (vlk)	5.7	18.9	17.6	0.863	1.9	13.62**
12.	Rac	1226.0(nzp)-53.5 (ckr)	38.7	17.2	14.0	0.660	9.1	4.89**
13.	Pcol	1.0(dhr,ls,rt1,uls,vlk) - 5.0	3.4	34.0	33.8	0.989	2.4	182.31**
14.	Tfl	423(nl.pk-4)-2925 (bpk)	1531.0	42.8	35.9	0.704	949.2	5.75*
15.	Htl	3.5(jeh) - 267.5(mlk)	98.9	70.3	62.7	0.794	113.8	8.70**
16.	Pem	1.5(vlk)-5.0 (nlg,nls,sj)	3.6	26.6	24.4	0.838	1.7	11.37**
17.	Dfl	23.5 (mlg)-66.5 (nl.him-46)	35.6	23.4	22.6	0.934	16.0	29.25**
18.	Ifs	1.0 (jeh)-12.9 (fzl)	5.2	56.2	47.9	0.724	4.4	6.26**
19.	Frt	0.062(jeh)-1.5 (nl,nl.pk-77)	0.5	48.9	43.7	0.798	0.4	8.92**
20.	Frn	27.0(jeh)-580.0(kpd)	215.4	62.9	55.9	0.790	220.4	8.53**
b. Fruit character								
21.	Frw	116.0(nek-1)-815.6(cjp)	307.7	48.9	48.4	0.982	304.0	109.62**
22.	Frv	120.3 (pht)-836.8 (btl)	304.0	50.2	49.8	0.985	309.5	131.80**
23.	Frl	6.8 (pht)-16.0(btl)	10.5	19.9	19.7	0.984	4.2	121.27**
24.	Fb1	5.6(dhr) - 11.3 (cjp)	7.7	17.3	17.2	0.987	2.7	88.45**
25.	Fb2	5.1(csr,nl)-10.2 (cjp)	6.9	17.2	17.0	0.976	2.4	82.09**
26.	P1w	5.9(loc-1)-70.6 (btl)	29.7	52.1	50.8	0.951	30.3	40.05**
27.	Rfw	104.7(nek-1)-747.5 (cjp)	278.0	49.5	49.1	0.981	278.3	103.52**
28.	Ppw	53.4(loc-1)-553.8(cjp)	187.7	55.1	54.3	0.972	207.0	70.81**
29.	Strw	16.9 (crp)-69.1 (jeh)	36.1	32.6	30.2	0.861	20.8	13.39**
30.	Tss	11.0(bg)-27.2 (ko-27)	17.2	21.6	19.7	0.832	6.3	10.92**
31.	Rs	1.6(loc-1)-26.8 (cjp)	7.8	68.0	64.2	0.893	9.8	17.64**
32.	Ts	6.2(nek-1)-64.9(jeh)	24.8	54.4	52.4	0.928	25.8	26.66**
33.	Tac	0.1(nek-2)-2.8 (btl)	0.4	93.0	89.1	0.918	0.7	23.47**
34.	Asc	2.3(loc-2)-42.7 (kpd)	9.9	79.0	75.7	0.918	0.7	23.47**
35.	Fbr	1.0(ckr,kdr)-4.9 (bpk)	2.8	34.5	34.2	0.984	2.0	126.04**
36.	Fir	1.0(kkn)-2.9(rtn)	2.2	17.9	16.6	0.866	0.7	13.88**
37.	Jui	1.1(jeh)-3.0(kkn)	2.0	19.5	18.4	0.896	0.7	18.26**
38.	Skc	1.1(nl.him-32)-6(csr,chl,nlg)	4.2	29.1	29.0	0.993	2.5	282.54**
39.	Ppc	1.3(fzl)-3.0(bg)	2.3	19.7	19.1	0.934	0.9	28.59**

Significant negative correlations were also recorded for fruit yield with fruit volume (-0.36), fruit yield with total sugars (-0.38) and fruit weight with total sugars (-0.27). These results are in confirmation with an earlier report which indicated that the bearing capacity in mango was linked to the inferior fruit quality, especially the low sugar contents (Sharma and Majumder, 1989).

Grouping of mango genotypes based on certain attributes of tree volume (tree size) as small ($< 40 \text{ m}^3$), medium ($40\text{-}80 \text{ m}^3$) and large ($> 80 \text{ m}^3$) in combination with the attribute of fruit yield (bearing capacity) as, shy bearer (< 150), average ($150\text{-}300$) and good bearer (> 300) is presented in Table 4. Twenty nine genotypes had small trees, with a mean tree volume of 22.9 m^3 , followed by 23 genotypes with medium size

trees, with a mean of 61.6 m^3 and 15 genotypes with large trees with a mean of 94.2 m^3 . Statistical analysis by the F test indicated that the groupings did not vary within a tree size attribute, but highly significantly varied between the attributes. The Chi-square test for homogeneity of variance in tree volume indicated that the variance was homogeneous for groups both within and between the attributes of tree size across the groups belonging to the bearing capacity. Similarly, groupings based on the bearing capacity have resulted in 28 shy bearers with a mean of 99.3 fruits, followed by 24 average bearers with a mean of 216.1 fruits and 15 good bearer genotypes with a mean of 396.7 fruits. The F test indicated that groupings did not vary within an attribute but highly significantly varied between the

Table 4. A two-way classification of mango genotypes based on tree volume and fruit bearing

Tree size (m^3)	Bearing capacity (fruits/tree)			Tree size Mean F value	Bearing capacity mean F value
	Shy bearers (<150)	Average bearers ($150\text{-}300$)	Good bearers (>300)		
Small (<40)	dlp, fzl, him, jeh, ko-11, rmm, csr, nl.him-33, nld, rtn, nek- 1, olr, vlk	ckr, crp, dps, loc-1, nzp, plh, sdr, nl.him-46, aur, pk, loc-4, kkn	nl, csr.nl, sj, nek-2	22.9 ^{NS} 2.79 ^{NS}	177.1 ^{**} 46.3 ^{**}
Medium ($40\text{-}80$)	alb, btl, bg, dr, fnd, ko-27, lgr, nl.him-32	ben, loc-2, nl. pk-4, nl. pk-78, nl.alb-92, nl.alb-94, mlk, ckr.kdr.pht	bms, kpd, mlg, pr, nl.him-63, nlg	61.6 ^{NS} 1.74 ^{NS}	234.7 ^{**} 40.1 ^{**}
Large (> 80)	chm, chs, cjp, kd, lpr, pdr, nl.him-3/7	ls, tp, nl.alb-137	alp, loc-3, rtl, nl.pk-77, nls	94.2 3.0 ^{NS} $\chi^2 =$ 1.34 ^{NS}	218.8 93.4 ^{**} $\chi^2 =$ 22.23 ^{**}
Tree size; Mean F value	49.2 ^{**} 159.3 ^{**}	46.1 67.4 ^{**}	67.3 82.7 ^{**}	52.2 76.3 ^{**}	—
$\chi^2 = 2.70^{\text{NS}}$					
Bearing capacity; mean; F value	99.3 1.0 ^{NS}	216.1	396.7 1.1 ^{NS}	-	206.3 0.48 ^{NS}
$\chi^2 = 6.152^*$					

Significant at *P = 0.05 and **P = 0.01; NS-non significant

attributes. However, the Chi-square test indicated the heterogeneous variance of fruit yield for groups of both within and between the attributes of bearing capacity across the groupings belonging to tree size. The medium tree size group had 6 genotypes (Baramasi, Kalepad, Mulgoa, Pairi, Neelum $\times$ Himayuddin-63 and Neelgoa), that were more productive (fruit yield mean 234.7) than the genotypes that exhibited large tree size (fruit, yield mean 318.8) and the genotypes of small trees (fruit yield mean 177.1). The F test also indicated very high significant differences among the groups. The most desirable attribute viz, the small tree size with good bearing capacity was noticed in Neelum, Suvarnarekha $\times$ Neelum, Swarna Jehangir and Nekkare-2.

Similarly, the classification of genotypes based on the bearing capacity and the irregularity index (Table 5) indicated that a maximum of 28

genotypes belonged to low irregularity with a mean of 12.7 per cent, followed by 25 genotypes in the moderate irregularity index group, with a mean of 31.4 percent, 9 genotypes in the high Ir group with a mean of 55.9 per cent and only 5 genotypes in very high irregularity index group alternate bearers) with a mean of 96.3 per cent. The Chi-square test indicated the presence of homogeneous variance of irregularity index in the entries. In general, significant differences were noticed in irregularity index levels due to the bearing capacity, where the average bearers recorded a maximum mean of 33.9 per cent irregularity index, followed by shy bearers with a mean of 31.6 per cent irregularity index and good bearers with a mean of 28.7 per cent irregularity index. Another most desirable attribute of the good bearing with low irregularity was noticed in Local-3, Pairi, Neeleshan and Nekkare-2. In

Table 5. A two-way classification of mango accessions based on bearing capacity and irregularity index

Bearing capacity (fruits/tree)	Ir index				Bearing capacity mean F value	Ir Index Mean F value
	Low (< 20%)	Moderate (20-50%)	High (50-80%)	Very high (81- 100%)		
Shy bearers	alb, bt1, chm, cjp, d1p, fnd, kid, ko-11, ko-27, rmn, nl.him-32, nl.him-33, rtn, nek-1, v1k	dhr, him, lgr, pdr, csr, nld, nl.him- 3/7, olr	chs, lpr	bg, fzl, jeh	99.3 1.55 ^{NS}	31.6 199.2**
Average bearers	ben, crp, loc-1, plh, sdr, tp, nl-alb-137, aur, loc-4	ckr, loc-2, nzp, nl.him-46, nl.pk-4, mlk, phr	dps, nl.pk-78, nl.alb-92, nl.alb-94, ckr.kdr, bpk, knn	ls	216.1 0.05 ^{NS}	33.9 90.6**
Good bearers	loc-3, pr, nls, nek-2	alp, bms, kpd, mlg, nl, nl.him- 63, nl.pk-77, csr.nl, nlg, sj	-	rtl	396.7 0.68 ^{NS} $\chi^2 = 5.74^{NS}$	28.7 122.1** $\chi^2 = 4.97^{NS}$
Bearing capacity	Mean F value $\chi^2 = 22.23^{**}$	176.4 70.5 261.1 50.0**	185.0 20.7*	156.7 13.52**	206.3 32.12**	—
Ir index	Mean F value $\chi^2 = 0.34^{NS}$	12.7 0.26 ^{NS} 31.4 3.06 ^{NS}	55.9 0.006 ^{NS}	96.3 0.12 ^{NS}	—	31.7 111.3**

Table 6. A three-way classification of mango genotypes based on fruit size, major and minor[#] fruit shape indices

Fruit size (cm ³)	Major shape indices (frl : fb1 ratio)						Mean		
	Round (< 1.26)		Oval (1.36-1.40)		Oblong (> 1.40)		F value		
	Cylindrical	Flat	Cylindrical	Flat	Cylindrical	Flat	Fruit size	Major shape	Minor shape
Small (< 200)	crp, kpd, nl, nl.him-32, pht	nl.pk-77, nek-1 nek-2	dps, knn	-	dhr, ko-11, ls, loc-1, rtl, nl.him-33, csr.nl	-	151.5	1.35	1.09
							0.92 ^{NS}	19.8 ^{**}	15.3 ^{**}
Medium (200-350)	kid, lpr, pr, rmn, nl.pk-78	ko-27, plh, nl.him-63, nlg	alp, fnd, lgr, csr, nl.him-46, nld, rtn, sj, loc-4	nls, bpk	bms, chm, chs, nlp, nl.alb-92, nl.alb-94, nl.alb-137, vlk	nlk, olr	272.5	1.34	1.12
							1.08 ^{NS}	22.8 ^{**}	8.3 ^{**}
Large (> 350)	bg, cjp, jeh, mlg, nl.pk-4, aur	sdr	dlp, loc-2, loc-3, nl.him-3/7	-	btl, ckr, him, tp	alb, ben, fzl, pdr, ckr, kdr	480.9	1.39	1.11
							0.48 ^{NS}	7.3 ^{**}	36.2 ^{**}
							$\chi^2 =$ 54.8 ^{**}	$\chi^2 =$ 7.9 [*]	$\chi^2 =$ 15.9 ^{**}
Fruit size									
Mean	-	302.2	-	-	286.3	-	-	317.2	-
F value		9.62 ^{**}			15.94 ^{**}			12.98 ^{**}	
major shape									
Mean	-0	1.15	-	-	1.34	-	-	1.56	-
F value		0.4 ^{NS}			0.3 ^{NS}			0.04 ^{NS}	
Minor shape									
Mean	1.08	1.11	1.18	1.09	1.11	1.21	1.09	1.11	1.17
F value	2.7 ^{NS}	101.2 ^{**}	2.1 ^{NS}	0.5 ^{NS}	24.1 ^{**}	-	42.0 ^{**}	70.5 ^{**}	4.0 ^{**}
F value	2.7 ^{NS}	101.2 ^{**}	2.1 ^{NS}	0.5 ^{NS}	24.1 ^{**}	-	42.0 ^{**}	70.5 ^{**}	4.0 ^{**}

#Minor shape index = Fb1:Fb2 ratio, where cylindrical = < 1.15 and flat = 1.15 and above)

Significant at *P = 0.05 and **) = 0.01; NS = non significant

addition to that, Nekkare-2 also exhibited a small tree size.

A classification of mango genotypes based on attributes such as fruit volume, fruit length:

major fruit-width ratio (as major shape index) and major fruit-width : minor fruit-width ratio (as minor shape index) has resulted in 15 out of a possible 18 groups of genotypes (Table 6). A maximum of 30 genotypes had medium sized fruits with a mean of 272.5 cm^3 , followed by 20 genotypes in the large fruit group, with a mean of 480.9 cm^3 and 17 genotypes with small fruits, with a mean of 151.5 cm^3 . A maximum of 26 genotypes belonged to the oblong shape, 24 genotypes in the round shape and 17 in the intermediate oval shape. In minor shape attributes, as many as 50 genotypes belonged to cylindrical, whereas the remaining 17 were of flat shape. The F test indicated non-significant difference between the groups within fruit size and also for major shape index, but significantly differed for the groups within an attribute of minor shape index, suggesting the ineffectiveness of the minor shape index for classification of mango genotypes though the Chi-square test indicated its homogeneity of variance.

Accessions with oval fruit shape and medium size were found in 9 genotypes, i.e. Alphonso, Fernandin, Langra, Suvarnakha, Neelum $\times$ Himayuddin-46, Neeluddin, Ratna, Swarna Jehangir and Local-4 and among these, rated for the attractive skin colour in the Alphonso (5.2), Suvarnakha (6.0), Ratna (5.3) and Swarna Jehangir (5.5). Similarly, the rating for pulp fibreness had indicated a low and negligible presence in Alphonso, Langra, and Swarna Jehangir. These results have confirmed the earlier observations realized by Sulikeri *et al.* (1994). Among the large fruited genotypes, low fibreness was noticed in Bombay Green, Mulgoa, AuRumani, Neelum $\times$ Himayuddin-3/7, Alampur Baneshan, Cherukurasan $\times$ Khader 18/16, Batlimavu, Cherukurasam, Himayuddin and Totapuri. High pulp fibreness was noticed in Sardar, Cowasji Patel, Hehangir, Neelum $\times$ Panchadarakalasa-4, Dilpasand, Local-2, Local-3,

Beneshan, Fazli and Peddarasam. However these large fruited genotypes need further testing for their suitability for canning or juice processing. In India most of the table varieties are said to have either slight or soft fibre, and those of sucking types are mostly juicy or soft fleshy with coarse fibres (Singh, 1990). The relative abundance of the fine fibre is a necessity to protect the interior of a fruit from bruising and internal collapse during handling and shipping but at the same time should be unobjectionable to the consumer (Knight, 1993; Iyer, 1991).

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CHARACTERIZATION OF MANGO GERMPLASM IN NORTH KARNATAKA, INDIA: 2. CLUSTER ANALYSIS

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Numerical taxonomic approach of unweighted pair group method using arithmetic average (UPGMA) in one of SAHN (sequential, agglomerative, hierarchical and non-overlapping) techniques of clustering methods, has resulted in 11 clusters amongst 67 genotypes. The canonical roots analysis after standardization of the data matrix for 37 quantitative and 6 qualitative characters has resulted in 78.1 per cent of the variation depicted in first 3 vectors. The major contributors to the diversity were the fruit characters upto 49.0 per cent, followed by the yield components (18.4%), panicle characters (11.5%) leaf characters (8.5%), tree size and shoot characters (8.4%) and the phenological characters (4.2%). Clusters 2, 4, 3 and 10 were most homogenous, whereas cluster 9, 7 and 11 were highly heterogeneous. Cluster 7 (Neelum, Baramasi, Kalepad) and cluster 11 (Batlimavu and Cowasji patel) were the most divergent, followed by cluster 10 (Dophasla, nl.him-46, Neeluddin, Local-4, KO-11, Creeping) and cluster 11, while the cluster 3 (Dashehari, Pahutan, nl.him-32, nl.him-33, Local-1, csr.nl, Nekkare-2, Nekkare 1) and cluster 10 were the least divergent.

Key words: *Mangifera indica*, cluster analysis, canonical roots, intra and inter-cluster distances

The nature of heritable variability in clonally propagated fruit species must be understood for the success of the breeding strategy. But, because of the high costs and the required land involved in maintenance of the trees, it may be difficult to keep very many entries in the germplasm (Chan, 1992). However it is essential to maintain optimum variability as it is connected to breeding relationships among the individuals. Multivariate statistical analysis has been used effectively in quantifying the degree of divergence in the germplasm in many crop species (Rao, 1952; Sneath and Sokal, 1973). In the numerical taxonomic approaches, generally the similarity coefficients or average Euclidean distances are used in concurrence with the principal component analysis or canonical roots analysis, to arrive at

more meaningful cluster formations. However such information is lacking in mango (*Mangifera indica* L.). The main objectives of the present study were therefore, to assess the degree of genetic divergence, its distribution pattern in relationship with geographic and ecological background, to identify the main contributing characters towards divergence and the most divergent parental groups that may likely lead to exploit the hybrid vigour for any chosen character.

MATERIAL AND METHODS

The data were collected from 67 genotypes for 2 successive years, during their 17-19 years of orchard life, at the College of Agriculture, Dharwad, Karnataka, India. All the characters as listed in part 1 were used here, except mean

fruit weight (*Fru*), ripe fruit firmness (*Fir*) and reducing sugars (*Rs*) which showed high correlations (0.99, 0.60 and 0.71) to fruit volume (*Frv*), juiciness (*Jui*) and total sugars (*Ts*) respectively. In addition, the ratings of certain qualitative characters of tree volume (*Tvq*, as : small-0, medium-1, large-2); fruit number per tree (*Frng*, as : shy-0, average-1, good-2); irregularity index (*Irq*, as: low-0, moderate-1, high-2, very high-3); fruit volume (*Frvq*, as: small-0, medium-1, big-2); fruit major shape index (*Shp1*, as :round-0, oval-1, oblong-2) and fruit minor shape index (*Shp2*, as: flat-0, cylindrical-1), were also utilized in the data set. The clustering method adopted was the numerical taxonomic approach as explained by Sneath and Sokal (1973). The standardized data (where $\mu = 0$ and $\sigma = 1$) were utilized to calculate average similarity coefficient (SG) between each pair of the 67 genotypes as given by Gower (1971). The cluster analysis was done by UPGMA (unweighted pair group method using arithmetic average) technique of the SAHN (sequential, agglomerative, hierarchic and non-overlapping) clustering methods and the taxonomic structure was presented in a dendrogram. The clusters were identified from the dendrogram at SG equivalent to 0.7. Both the intra and intercluster distance coefficients were computed and the cluster means for all the variables were subjected to ANOVA (analysis of variance) for group comparisons. The canonical roots analysis was carried out with the standardized data set to arrive at Eigen values and vectors.

RESULTS AND DISCUSSION

The canonical roots analysis of 37 quantitative and 6 qualitative characters of all the 67 genotypes revealed that the first three vectors could explain up to 78.1 per cent of the total variation (Table 1). The major contributors to the genetic diversity were minor fruit-width (4.3%), fruit yield (4.2%), major fruit -width (4.2%), ripe fruit weight (4.1%),

fruit volume (4.1%), fruit number per tree (4.0%), pulp weight (3.9%), physiological loss of weight (3.8%), bearing panicles (3.5%), fruit length (3.5%), fruit volume per tree-frvq (3.4%), total sugars (3.3%), leaf length (3.2%), stone weight (3.2%), leaf area (3.2%), fruit retention (3.1%) and tree volume (3.0%), accounting for 62.0 per cent of the total divergence. The external fruit characters (fruit volume, fruit retention, major fruit-width, minor fruit-width, physiological loss of weight, ripe fruit weight, ripe fruit skin colour, Frvq, major shape index and minor shape index) have contributed upto 29.6 per cent, whereas the internal fruit characters (pulp weight, stone weight, total soluble solids, total sugars, titratable acidity, ascorbic acid content, pulp fibreness, juiciness of pulp content and pulp colour) have contributed upto 19.4 per cent and together contributing upto 49.0 per cent of the total variation. Thus fruit characters were the most important for explaining the genetic variability in mango. These results have also confirmed the earlier report by Suman *et al.* (1985) that the fruit size and shape factor was accounted for 58.3 per cent of total variation among the 84 cultivars studied. In the present study other sets of characters, that have contributed considerably were the fruit yield components (panicles per tree, bearing panicles, initial fruit set, fruit retention, fruit yield, irregularity index, fruit no. per tree and irregularity index) upto 18.4 per cent, followed by the panicle characters (length of panicle, thickness of primary rachis, total flowers per panicle, rachii per panicle and colour of primary rachis) with 11.5 per cent, leaf characters (leaf length, maximum leaf width, and leaf area) with 8.5 per cent, tree size and shoot characters (tree volume, bearing shoot length, proximal shoot length, leaves per shoot and qualitative characters of tree volume) with 8.4 per cent and the phenological characters (period of panicle emergence and duration of flowering) with only 4.2 per cent, towards the total variation. The pattern of istribution of the 67 entries in

Table 1. Canonical roots and vectors of 43 characters from 67 mango genotypes

Character		Vector 1	Vector 2	Vector 3	Contribution towards diversity (%)
Tree volume	m ³	0.161	0.34	0.12	3.0
Bearing Shoot length	cm	-0.06	0.03	0.17	1.0
Proximal shoot length	cm	-0.06	-0.09	0.12	1.2
Leaves/shoot	No.	0.05	0.01	-0.01	0.4
Leaf length	cm	0.14	0.34	0.35	3.2
Max. leaf width	cm	0.09	0.06	0.48	2.1
Leaf area	cm ²	0.13	0.19	0.47	3.2
Period of panicle emergence	rating	0.07	0.30	-0.08	2.2
Panicles/tree	No.	-0.03	0.21	-0.27	2.0
Bearing panicles	No.	-0.04	0.59	-0.16	3.5
Length of panicles	cm	0.07	0.13	0.28	1.5
Thickness of primary rachis	mm	-0.06	0.13	0.37	2.0
Rachis/panicle	No.	0.05	0.32	0.22	2.5
Colour of primary rachis	rating	-0.03	-0.06	0.15	0.9
Total flowers	No.	0.22	0.14	0.14	2.4
Hermaphrodite flowers	No.	0.04	0.35	0.16	2.3
Flowering duration	days	-0.10	-0.29	0.10	2.0
Initial fruit set	No.	0.02	0.09	0.13	0.8
Fruit retention	No.	-0.14	0.41	0.08	3.1
Fruit yield	No.	-0.15	0.58	-0.16	4.2
Irregularity index	Per cent	0.01	-0.08	0.08	0.6
Tree volume		0.14	0.29	0.22	2.8
Fruit no. per tree		-0.16	0.55	-0.11	4.0
Irregularity index per tree	-0.01	0.01	-0.06	0.2	
Fruit volume	cm ³	0.59	-0.04	-0.02	4.1
Fruit length	cm	0.51	-0.03	0.04	3.5
Major fr. width	cm	0.55	-0.08	-0.07	4.2
Major fr. width	cm	0.55	-0.11	-0.08	4.3
Physiological loss of weight	g	0.51	-0.08	-0.07	3.8
Ripe fr. weight	g	0.59	-0.04	-0.03	4.1
Pulp weight	g	0.59	-0.02	-0.02	3.9
Stone weight	g	0.46	-0.04	-0.02	3.2
Total soluble slides	"brix	0.02	-0.16	-0.03	1.0
Total sugars	g	0.55	-0.11	-0.05	3.3
Titrate acidity	g	0.40	0.00	-0.02	2.1
Ascorbic acid content	mg	0.23	0.05	-0.19	2.3
Pulp fibre content	rating	-0.14	-0.02	0.08	1.3
Juiciness of the pulp	rating	-0.03	0.17	0.14	1.3
Ripe fruit skin colour	rating	0.07	-0.03	-0.05	0.8
Pulp colour	rating	-0.04	-0.08	0.10	1.0
Fr. no. per tree		0.53	-0.01	0.00	3.4
Fruit major shape index		0.04	0.03	0.10	0.7
Fruit minor shape index		-0.03	-0.06	-0.05	0.7
Eigen Root		19.00	10.29	4.28	-
% Var. Explained		44.22	23.93	9.95	-
Cum. Perc. Var.		-	68.15	78.10	100.0

11 clusters is depicted in Table 2 and were clearly identified from the dendrogram (Fig. 1). A maximum of 12 genotypes were recorded in cluster 8 followed by cluster 5 with 10 genotypes, cluster 3 and cluster 6 with 8 genotypes each, cluster 1 and cluster 10 with 6 genotypes each, cluster 2 with 5 genotypes, cluster 4 with 4 genotypes, cluster 7 and cluster 9 with 3 genotypes

Table 2. Cluster compositions based on SAHN multivariate technique involving 67 mango genotypes

Cluster	Frequency	Accessions
1	6	Alphonso, Pairi, Neelgoa, Swarna Jehangir, Neeleshan, Local-3.
2	5	Chandramaru, Fernandin, Chausa, Lal Pairi, Neelam $\times$ Himayuddin 3/7
3	8	Dashehari, Pahutan, Neelam $\times$ Himyuddin-32, Neelam $\times$ Himdyuddin-33, Local-1, Suvernrekha $\times$ Neelam, Nekkare-1, Nekkare-2
4	4	Suvernrekha, Olour, Ratna, Bappekshi
5	10	Lucknow Safeda, Neelam $\times$ Pamchadarakalasa-77, Rataul, Neelam $\times$ Alampur Baneshan 137, Neelam $\times$ Himayuddin-63, Neelam $\times$ Panchadarakalasa-4, Neelam $\times$ Alampur Baneshan-92, Neelam $\times$ Alampur Baneshan-94, Mallika, Suvernrekha $\times$ Khader
6	8	Kari Isbad, Langra, Nazuk Pasand, Neelam $\times$ Panchadarakalasa-4, Pulihora, Kurukkank-27, Ruman
7	3	Neelam, Beramasi, Kalepade
8	12	Baneshan, Cherukuram, Alampur Baneshan, Dilpasand, Himayuddin, Bombay Green, Sardar, Au Ruman, Fazli, Vellaikolamban, Local-2, Totapuri
9	3	Peddadasam, Mulgoa, Jehangir
10	6	Dophasala, Neelam $\times$ Himayuddin-46, Neeluddin, Local-4, ko-11, creeping
11	2	Batlimavu, Cowasji Patel

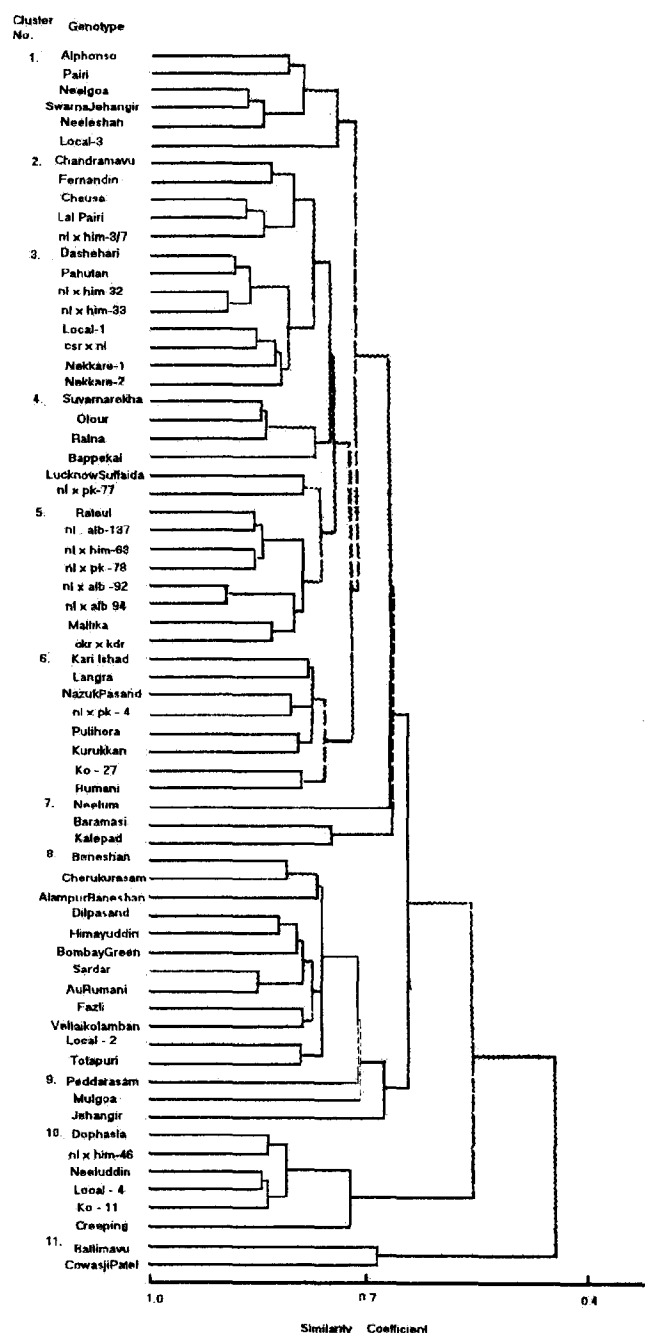


Fig. 1. Dendrogram showing heirarchical clustering of 67 mango genotypes based on similarity coefficient in 43 characters

each and cluster 11 with only 2 genotypes. The criterion used for clustering was that any two genotypes falling in the same cluster would show smaller genetic distance than those belonging to any other cluster. A perusal of the cluster

Table 3. Average intra(bold) and inter cluster distances

Cluster	1	2	3	4	5	6	7	8	9	10	11
1	5.51	7.60	8.38	8.06	6.35	8.60	7.79	7.64	9.25	9.28	11.26
2	-	4.30	6.34	5.81	5.96	5.89	5.49	6.73	8.28	6.76	11.53
3		-	4.82	5.92	6.31	6.53	8.15	8.38	10.27	5.35	14.57
4			-	4.62	6.37	5.97	8.84	6.33	7.99	5.70	11.98
5				-	5.34	6.81	7.66	7.05	8.72	6.96	12.37
6					-	5.80	9.04	7.31	8.46	6.30	12.05
7						-	7.32	9.81	11.02	8.85	14.72
8							-	6.04	8.34	8.14	9.75
9								-	7.33	9.82	9.71
10									-	4.95	14.11
11										-	6.93

compositions (Table 2) indicated that cluster 1 had accessions mostly from the peninsular India, but cluster 2 which is represented by the 4 peninsular cultivars, also had Chausa, a popular north Indian cultivar. Similarly, in cluster 3 only Dashehari was from the north Indian origin, whereas the rest of them belonged to the peninsular region. The clustering pattern of these accessions suggested that geographic diversity may not necessarily be related with genetic diversity. Therefore, the selection of parental lines for hybridization in mango should be based on genetic diversity rather than on the geographic diversity. Estimations of intra cluster distances indicated (Table 3) that the cluster 2 with 5 accessions (Chandramavu, Fernandin, Chausa, Lalpairi and Neelam $\times$ Himayuddin-3/7) had the least average distance (4.3), followed by cluster 4 (4.62), cluster 3 (4.82) and cluster 10 (4.95) and suggested that the accessions falling within these clusters were more homogeneous than the accessions of other clusters, while the clusters 8, 6, 1 and 5 were

moderately heterogeneous whereas cluster 9, with 3 accessions (Peddarasam, Mulgoa and Jehangir) recorded the maximum average intracluster distances (7.33), followed by cluster 7 (7.32) and cluster 11 (6.93). Thus, the accessions falling within these clusters were highly heterogeneous. The average inter cluster distances revealed a maximum between cluster 7 and 11 (14.72) followed by cluster 3 and 11 (14.57), and cluster 10 and 11 (14.11). This indicated that cluster 11 (Batlimavu and Cowasji Patel) was highly divergent with cluster 3 (Dashehari, Pahutan, Neelam $\times$ Himayuddin-32, Neelam $\times$ Himayuddin-33, Local-1, Suvernekha $\times$ Neelam, Nekkare-2 and Nekkare-1), cluster 7 (Neelum, Baramasi and Kalepad) and cluster 10 (Dophasla, Neelam $\times$ Himayuddin-46, Neeluddin, Local-4, Ko-11 and Creeping). The minimum average distance coefficient recorded between cluster 3 and 10 (5.35) indicated that the genotypes in these two clusters were relatively closer to each other. Similarly the lower intercluster distances were also recorded within the cluster pairs 2-4, 2-5, 3-4, 4-6 and 4-10 which indicated their closer relationships. Cluster means of the 37 quantitative characters are presented in Table 4 and the group differences for all these characters were significant by the statistical analysis. A perusal of these cluster means indicated that fruit yield (*Frn*) was maximum in cluster 7, minimum tree size (*Tv*) in cluster 4, maximum fruit size (*Frv*) in cluster 11, high Tss in cluster 9, attractive fruit skin colour (*Skc*) in cluster 4. Likewise, several other desirable attributes would be pin pointed from the cluster mean values. Hybridization between accessions falling in the most distant clusters (11 and 3 or 7) would be expected to result in a maximum hybrid vigour and eventually the desirable segregates. Also the hybridization of cluster 11 with the cluster 10 should result in desirable combinations leading to the development of useful genetic stocks.

Table 4. Cluster means of 37 characters in mango

Character		Cluster Number											Group Comparisons		
													CD		
Trait	Unit	1	2	3	4	5	6	7	8	9	10	11	SEd	5%	1%
Tree volume	m ³	79.0	82.1	37.3	16.4	71.5	40.3	55.0	46.4	57.0	22.7	91.2	9.6	19.3	25.8
Primary sheet length	cm	9.7	9.7	11.7	9.2	11.1	9.5	11.3	11.1	10.0	10.0	10.2	0.9	1.9	2.4
Proximal shoot length	cm	6.9	8.1	11.4	7.2	9.6	7.8	8.7	7.9	6.3	7.3	8.3	1.2	2.4	3.2
Leaves per shoot	No.	13.7	13.1	13.0	12.9	12.6	12.4	12.1	11.7	11.6	11.5	9.7	0.8	1.7	2.3
Leaf length	cm	21.5	21.1	18.9	18.7	18.6	17.1	17.1	17.0	16.1	15.4	14.3	0.7	1.5	2.0
Max. leaf width	cm	5.2	5.1	4.7	4.6	4.7	4.2	3.6	5.1	4.2	4.2	6.0	0.3	0.7	0.9
Leaf area	cm ²	78.7	68.2	59.7	56.8	63.0	48.1	45.4	70.6	44.0	50.4	92.0	6.3	12.8	17.1
Period of panicle emergence	rating	4.5	4.2	3.2	3.5	3.9	3.7	3.8	3.5	3.3	2.5	3.2	0.3	0.7	0.9
Panicle per tree	No.	502.2	205.9	445.8	430.0	467.0	331.8	920.5	473.2	576.3	478.3	273.5	99.3	200.2	267.6
Bearing panicles	No.	305.1	90.1	150.0	141.0	195.9	122.8	322.5	146.3	142.0	113.1	126.7	23.9	48.2	64.4
Length of panicles	cm	29.2	26.1	3.3	24.2	29.0	22.8	26.6	30.3	24.4	26.9	23.6	2.0	4.1	5.4
Thickness of primary rachis	mm	5.3	5.7	5.5	6.0	6.1	5.7	4.6	5.9	5.7	5.8	5.4	0.4	0.9	1.1
Rachii per panicle	No.	44.7	37.7	37.6	37.5	42.9	30.3	38.5	42.1	39.2	34.9	33.8	1.9	3.8	5.1
Colour of primary rachis	rating	3.2	4.0	3.7	3.7	2.8	3.6	3.3	3.5	3.7	3.5	3.5	0.5	1.0	1.2
Total flowers	No.	1709	1111	1311	2171	1528	787	1631	1956	2134	1184	2065	190	383	512
Hermaphrodite flowers	No.	160.9	73.9	74.6	52.0	121.9	73.1	177.4	107.7	74.5	58.1	141.8	24.6	49.6	66.3
Flowering duration	days	29.7	32.2	34.6	37.0	35.5	34.2	31.0	35.5	35.6	50.9	32.6	2.8	5.7	7.6
Initial fr. set	No.	4.2	5.3	4.7	3.3	5.9	6.3	8.0	5.5	3.0	5.2	2.9	1.1	2.2	2.9
Fr. retention	No.	0.8	0.5	0.5	0.4	0.7	0.4	0.8	0.4	0.4	0.5	0.6	0.1	0.2	0.3
Fr. yield	No.	369.4	110.2	201.4	158.7	269.5	145.2	541.8	148.7	150.3	155.2	126.7	31.8	64.2	85.8
Irregularity index	percent	18.3	32.6	23.4	38.6	48.9	26.4	23.4	33.1	62.1	26.1	11.4	9.7	19.7	26.1
Fr. volume	cm ³	314.0	280.7	151.1	283.2	247.9	280.9	174.2	431.1	517.4	187.1	820.3	30.0	60.5	80.9
Fr. length	cm	10.2	10.6	8.4	11.1	10.2	9.6	8.9	12.4	12.7	9.0	14.9	0.6	1.2	1.6
Major fruit width	cm	7.9	7.8	6.2	8.0	7.2	8.0	6.5	8.8	9.6	6.6	11.1	0.3	0.6	1.2
Minor fr. width	cm	7.1	7.0	5.5	7.0	6.4	7.2	5.9	7.8	8.7	6.1	10.0	0.3	0.6	0.8
Physiological loss of wt	g	31.1	29.0	14.3	31.1	25.2	26.7	16.1	44.3	38.6	19.7	69.3	4.3	8.6	11.5
Ripe fr wt	g	283.4	258.8	136.3	259.4	228.4	262.2	166.0	388.7	478.9	172.3	745.3	26.9	54.2	72.4
Pulp wt	g	198.1	157.2	85.0	167.5	153.8	174.5	102.7	274.7	312.9	113.8	547.5	20.5	41.4	55.3
Stone weight	g	39.2	42.6	25.5	36.0	32.3	36.8	25.6	38.0	61.2	27.8	59.6	3.2	6.4	8.6
Total soluble solids	brix	14.8	16.9	17.4	17.9	17.7	17.4	15.8	17.8	20.0	17.0	13.7	1.5	3.0	3.9
Total sugars	g	22.3	21.0	11.9	22.4	21.1	26.1	13.3	36.3	48.7	14.5	55.5	3.4	6.8	9.1
Titrate acidity	g	0.4	0.3	0.2	0.3	0.3	0.5	0.3	0.4	0.6	0.3	1.9	0.1	0.2	0.3
Ascorbic acid content	g	6.9	5.9	3.8	8.4	6.7	13.4	26.6	11.2	13.4	8.6	23.5	2.4	4.8	6.5
Pulp fibre content	rating	2.1	2.7	3.0	3.6	3.4	2.8	2.6	2.4	2.9	3.0	2.9	0.4	0.8	1.1
Juiciness of the pulp	rating	1.9	1.9	1.9	1.7	2.4	2.2	2.0	2.1	2.1	2.0	2.1	0.1	0.3	0.4
Ripe fr. skin colour	rating	4.6	4.8	3.9	5.3	3.4	4.8	4.0	4.4	4.0	3.6	4.6	0.5	1.0	1.3
Pulp colour	rating	2.3	2.4	2.6	2.2	2.3	2.3	2.1	2.1	2.3	2.3	2.6	0.2	0.3	0.4

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EVALUATION AND CLASSIFICATION OF FACULTATIVE AND WINTER WHEAT GERMPLASM

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One hundred and sixty seven exotic facultative and winter wheat germplasm collections were evaluated for 4 characters using non- hierarchical Euclidean analysis. All the genotypes were grouped into 11 different clusters showing existence of high genetic diversity in the material. The intra cluster distance was maximum (1.222) in cluster VII and minimum (0.607) in cluster I. Cluster one and eight were highly diverse (3.99) from each other. Donors for plant height, test weight, days to 50% heading and grain yield/plant were identified.

Key words : *Triticum aestivum*, evaluation, divergence

Wheat (*Triticum aestivum* L. em Thell.) is one of the important cereal crop of India. With 68.2 mt production and 27 q/ha productivity in 1997-98, India has now become second largest producer of wheat in the world. To further enhance the productivity a thrust on collection and evaluation of facultative and winter wheat germplasm is being given to identify donor parents for genetic restructuring of genotypes towards resistance to biotic and abiotic stress and to harness new yield genes. For identifying genetically diverse parents for hybridization, multivariate analysis (Mahalanobis D^2 statistic) has been used in spring wheat (Bhatt, 1970; Singhal and Upadhyay, 1977; Jatasra and Paroda, 1978, Garg and Gautam, 1997) and in winter wheat (Jag Shoran and Tandon, 1995). Multivariate analysis based on Mahalanobis D^2 statistic and canonical analysis have the limitations for classifying huge germplasm collections (Arunachalam, 1981). However, Beale (1969) suggested the use of Non-Hierarchical Euclidean analysis to overcome these limitations. As, the utility of this analysis for choosing parents for generating good segregates

has received very little attention. Hence the present investigation was undertaken to study the nature and extent of genetic variability and divergence in the 167 germplasm lines and to identify the donors for yield and yield contributing characters.

MATERIALS AND METHODS

The experimental material consisted of 167 exotic facultative and winter wheat germplasm and six check varieties viz., Bez, Seri, BLL, GRK, ATAY 85 and VL 6161. These genotypes were evaluated during *rabi* 1997-98 in an augmented design at the VPKAS Experimental Farm, Hawalbagh (Almora) situated at an altitude of 1250 m. Each plot consisted of two rows, each 2.8 meter long with 23 cm row to row and 10 cm plant to plant distance. Recommended package of practices were followed to raise a healthy crop. Observations were recorded on four quantitative characters days to 50 per cent heading, plant height (cm), grain yield (g/plot) and test weight (g). Five plants were randomly selected for recording the observation on plant height. Rest of the observation were recorded on plot basis.

Genetic divergence was studied using Non-Hierarchical Euclidean cluster analysis (Beale, 1969 and Spark, 1973). The SPAR 1 package developed by IASRI, New Delhi was used for classifying the genotypes.

RESULTS AND DISCUSSION

The general means, coefficient of variability and range for different characters are given in Table 1. For an effective breeding programme, existence of sufficient genetic variability is a prerequisite. In the present study, range for various characters showed wide variations, suggesting sufficient scope for further improvement for these traits. Further variability can be incorporated in other characters by hybridization among distant accessions.

Table 1. Range, mean, check mean and coefficient of variation for various characters

Characters	Days to 50% flowering	Plant height (cm)	Grain yield (g/plot)	Test weight (g)
Mean	155.58	107.54	525.09	36.74
Range	111-176	80-145	210-1040	22.9-54.4
Best check mean	119.67	100	826.67	43.67
C.V.	11.16	12.95	26.74	15.84

The classificatory procedures for ear marking, distant genotypes have been emphasized by several scientists (Griffing and Lindstrom, 1954; Moll *et al.*, 1962, Arunachalam, 1981). Non-Hierarchical Euclidean analysis has been found quite useful for estimating the genetic divergence

utilizing unreplicated data in the large germplasm collections. In this case, all the variables were converted to single index of similarity in the form of principal component. The eigen vectors, roots and associated variance have been given in Table 2. The maximum variation 54.30 per cent was explained by first latent vector followed second vector (24.56%). Thus around 78% variation was explained by first two vectors & rest of other two.

Table 2. Eigen root vector, eigen roots and associated variances for different components in winter wheat germplasm

Characters	1	2	3	4
1. Days to 50% heading	0.570	-0.315	-0.510	-0.562
2. Plant height (cm)	0.372	0.825	0.270	-0.330
3. Grain yield (g/plot)	0.084	-0.453	0.799	-0.386
4. Test weight (g)	0.728	-0.122	0.170	0.653
Eigen roots	2.172	0.978	0.558	0.292
% Variation	54.30	24.56	13.94	7.29

All the 167 genotypes have been grouped into 9 different non-overlapping clusters. The appropriate cluster arrangement as determined by F test revealed that the 9 clusters were most suited. Cluster I is the smallest containing only three accessions which had the highest values for test weight (51.57 g) and lowest values for days to 50 per cent heading (120 days) and grain yield (376.67 gm). Cluster II consisted of the highest number of accessions (37) with moderate values, while cluster III consists of 10 accessions which had the highest value for plant height

Table 3. Characters mean in different clusters of winter wheat

Characters	I(3)	II(37)	III(10)	IV(2)	V(19)	VI(23)	VII(16)	VIII(15)	IX(22)
Days to 50% heading	120.00	162.68	139.20	167.77	128.42	171.35	134.00	166.33	159.09
Plant height (cm)	101.67	103.65	133.00	122.73	98.95	90.00	114.38	102.33	112.50
Grain yield (g/plot)	376.67	447.03	572.00	488.18	541.05	383.04	804.38	491.33	646.82
Test weight (g)	51.57	38.66	41.39	32.66	40.39	30.95	43.72	28.35	37.01

Table 4. Average intercluster and intracluster distance D values among 9 clusters in winter wheat germplasm

	1	2	3	4	5	6	7	8	9
1	0.607								
2	3.266	1.037							
3	2.072	2.618	1.137						
4	3.387	1.802	2.498	1.021					
5	2.355	1.926	2.624	3.155	1.062				
6	3.103	1.650	2.655	2.376	2.137	0.854			
7	3.580	2.216	2.206	2.515	2.016	2.402	1.222		
8	3.991	1.890	2.340	1.713	2.898	1.384	2.249	0.746	
9	3.160	1.693	1.964	1.704	2.246	2.853	2.211	2.126	0.929

and VIII were located at the maximum diverse ends. The generalized intra-cluster distance (D) ranged from 0.607 (Cluster I) to 1.222 (Cluster VIII). Therefore, broadly it can be concluded that relatively less genetic divergence exists in Cluster I while individuals in Cluster VIII are more genetically divergent.

The minimum inter-cluster distance (1.38) was found between Cluster VI and VIII while reverse was true for Cluster I & VIII (3.99). This situation reflected the relative divergence of clusters which allows a convenient selection of a group of genotypes for any hybridization programme facilitating better exploitation of

Table 5. Minimum and maximum values for morphological traits in winter wheat germplasm

Character	Minimum			Maximum		
	Name	Value	Group	Name	Value	Group
Days to 50% heading	89 Zhong 228	132	V	TRAKIA/KNR, ODESSKAY 132, MIRLEBEN	176	II,VI,VI
Plant height (cm)	VORONA, ODESSKAY 132, KHVYLYA ERYTHROSPERMUM 896-89	80	VI,VI, VI,VI	47A*2.OGOSTA	145	III
Grain yield (/plot)	1.27.7876/CONDOR	210	II	MOMCHIL.KATYA	1040	VII
Test weight (g)	CO 900777	22.9	IV	WU GENG 8025	544	I

(133.00 cm). Cluster IV, V and IX contained 22, 19 and 22 accessions respectively and these had moderate values. Cluster VI consisted of 23 accessions and with highest value for days to 50% heading (171.35) while reverse was true in case of plant height (90.00 cm), Cluster VII had 16 accessions, which had highest values for grain yield/plot (804.38 g/plot), Cluster VIII contains 15 accessions and had lowest value for test weight (28.35 g). All cluster have exotic strains suggesting wide spectrum of genetic diversity among exotic germplasm.

The average inter and intra cluster distances are presented in Table 4 indicated that cluster I

germplasm resources. Thus hybridization between Cluster I and VIII may be helpful in developing heterotic combination to derive desirable recombinants.

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INCORPORATION OF SUPERIOR NUTRITIONAL QUALITY TRAITS IN INDIAN *B. juncea*

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The presence of high erucic acid in the seed oil and high glucosinolate in the oil free meal limit the global utilization of Indian rapeseed mustard. In order to reduce the levels of erucic acid and glucosinolate in Indian mustard, *B. juncea* var. Varuna was crossed with low erucic acid *B. juncea* strains Zem-1 and TERI (OE)M21, and the low glucosinolate line BJ-1058 for transfer of low erucic/low glucosinolate characteristics. Simultaneously, a unique three way cross; *B. juncea* (var. Varuna $\times$ Zem-1) $\times$ BJ-1058 was made for transfer of double low characteristics. The fatty acids and glucosinolates were analyzed and monitored through improved methods of GC and HPLC respectively. The progenies of selected plants were advanced through pedigree method and recurrent selections. The paper reports the transfer of low erucic acid (0- 1.5%), low glucosinolate (9-25 $\mu\text{m/g}$ oil free meal) and double low (0% erucic acid and 10-27 μm glucosinolate/g oil free meal) characteristics in *B. juncea* var. Varuna.

Key words : *B. juncea*, *B. napus*, erucic acid, glucosinolate, double low, rapeseed mustard

Brassica, commonly known as rapeseed mustard, is an important group of crop species being utilized as vegetables, condiments and edible oils. Among the oleiferous brassicas, approximately 80 per cent of the cultivated area is covered by *B. juncea*, the remaining being shared by *B. campestris* and *B. napus*. Altogether, they constitute a significant 25-30 per cent of the edible oilseeds produced in the country, thus contributing significantly to the national economy. The mustard oil is bestowed with lowest amounts of saturated fats, as compared to any other vegetable oil, and is a good source of the two essential fatty acids, linoleic and linolenic. The oil free meal is rich in proteins with well-balanced amino acids and minerals, and is a good source of animal feed. However, the rapeseed mustard varieties presently being grown in India have high amounts of erucic acid (40-50%) in the seed oil and glucosinolate

(80-160 μg) in the oil free meal. Experiments conducted on birds and animals suggested the adverse effects of diets rich in erucic acid (Gopalan *et al.*, 1974; Kumar and Tsunoda, 1980) and glucosinolate (Bille *et al.*, 1983; Bell, 1984). This led to the global research efforts towards lowering these two nutritionally harmful components. Consequently, the double low or 'OO' rapeseed varieties having less than 2 per cent erucic acid in the seed oil and less than 30 μm glucosinolate/g oil free meal were developed and commercialized in Canada and European countries ('Canola' quality; Downey 1990; Scarth 1995). These exotic canola quality rapeseed varieties were not found suitable to grow under Indian agroclimatic conditions (AICRP R&M, 1994), necessitating the research efforts for developing Canola quality rapeseed mustard varieties suitable to grow in India. The present work reports transfer of low

erucic acid, low glucosinolate and double low characteristics in *B. juncea* var. Varuna.

MATERIALS AND METHODS

B. juncea var. Varuna selected for transfer of low erucic acid/low glucosinolate/double low characteristics was used as a female parent. The exotic low erucic acid *B. juncea* var. Zem-1, the early maturing low erucic acid *B. juncea* strain TERI(OE)M21 (INGR No. 98001) and the low glucosinolate line BJ-1058 were used as pollen donors. For the transfer of low glucosinolate, reciprocal crosses of *B. juncea* var. Varuna and BJ-1058 were attempted. For the transfer of double low characteristics, a three way cross (Varuna $\times$ Zem-1) $\times$ BJ-1058 was attempted.

The seeds of the female parent and pollen donors were sown in field/pots during the month of October following the recommended agricultural practices. Flower buds on selected inflorescences of the female parent. *B. juncea* var. Varuna were emasculated manually with the help of forceps and pollinated with pollen from freshly opened flowers of the respective male parent (as above). The F₁ seeds were harvested. Some of the F₁ plants of the cross *B. juncea* var. Varuna $\times$ BJ-1058 and Varuna $\times$ Zem 1 were backcrossed with Varuna to generate BC₁F₁ seeds. The F₁ plants of the cross Varuna $\times$ Zem-1 were also used for crossing with BJ-1058 to generate F₁ seeds of the three way cross. The F₁ and BC₁F₁ plants were grown and selfed to harvest F₂ and BC₁F₂ seeds. During next generation, the self and open pollinated (OP) F₃ and BC₁F₃ seeds were collected from a large number of individual plants.

The F₁ seeds of the cross *B. juncea* var. Varuna $\times$ Zem-1/M-21 were analyzed for their fatty acids content by an efficient GC method through the bulk method (Kaushik and Agnihotri 1997). The F₂ and BC₁F₂ seeds were analyzed

by half seed technique (Downey and Harvey, 1963) to select plants having less than 2 per cent erucic acid. The seeds were germinated on a moist filter paper. The 24-36 hrs germinating seeds were hand pressed to remove the seed coat. The inner cotyledon with attached radicle was mounted in the numbered microtitre plates containing sterile MS basal medium and kept in culture room at 25°C. The outer cotyledon was used to analyze the fatty acids, and the low erucic acid plants were raised from the corresponding cotyledons in pots. The F₃ to F₅ plant progenies were raised following the pedigree method and recurrent selections. The plants were selected for early maturity and good agronomic attributes, selfed, and the self and OP seeds were collected in each generation. The harvested seeds were analyzed for their fatty acids content to confirm the quality characteristics. The F₆ plant population of the low erucic acid selections was grown in the field during Rabi 1997-98 for evaluation of yield potential and agronomical data was recorded.

The F₃ OP seeds of the crosses *B. juncea* var. Varuna $\times$ BJ-1058, BJ-1058 $\times$ Varuna, (Varuna $\times$ Zem-1) $\times$ BJ-1058 and the BC₁F₃ seeds of the cross (Varuna $\times$ BJ-1058) $\times$ Varuna were analyzed for their glucosinolate content by an improved HPLC method (Kaushik and Agnihotri, 1999). The selfed seeds of the plants, showing less than 30 μ m glucosinolate/g oil free meal in the OP seeds, were utilized to grow single plant progenies during the next three subsequent generations following the pedigree method and recurrent selections. The plant progenies were grown and selfed, and the self and OP seeds were harvested from individual plants. The glucosinolate content was analyzed from OP seeds in each generation to select plants having glucosinolate less than 30 μ m/g oil free meal. Simultaneously the plants were selected for early maturity in each generation.

The F₆ selfed seeds of the plants, from the cross *B. juncea* var. (Varuna × Zem-1) × BJ-1058 having less than 30 µm glucosinolate/g oil free meal, were analyzed for their fatty acids content. The double low plants having less than 2 per cent erucic acid in the seed oil and less than 30 µm glucosinolate/g oil free meal were identified for further progeny advancement. The F₆ single plant progenies of the double low *B. juncea* thus derived and the low glucosinolate selections derived from the cross *B. juncea* var. varuna × BJ-1058 were grown in the field during Rabi 1998-99 for collection of selfed and OP seeds. Selections were made for early maturity.

RESULTS AND DISCUSSION

Transfer of low erucic acid

The erucic acid content in the F₁ seeds of the crosses *B. juncea* var. Varuna × Zem-1/M-21 were intermediate (30- 35%) as compared to the high erucic acid parent Varuna (42%) and low erucic acid donor Zem-1/M-21 (0-2%). The erucic acid content in the BC₁F₂ seeds of the cross *B. juncea* var. (Varuna × Zem-1) × Varuna ranged from 23-52 per cent and none of the plants having low erucic acid could be realized. The erucic acid in the F₂ seeds ranged from 0-52 per cent in the cross Varuna × Zem-1 and 0-53 per cent in the cross Varuna × M-21. The erucic acid content in the seeds of single plant progenies of *B. juncea* var. Varuna derived from selected half seed having zero erucic acid, in the present study, remained 0-2 per cent in the subsequent generations (F₃ to F₆). In general the strains derived from the cross *B. juncea* var. Varuna × Zem-1 were late in maturity (140-145 days), tall and poor in agronomic attributes, as compared to those derived from *B. juncea* var. Varuna × M-21, which were comparatively early in maturity (135-140 days) and were further utilized for progeny advancement to derive the low erucic acid strains.

Table 1. The important agronomic and quality characteristics of the low erucic acid mustard (LEM), low glucosinolate mustard (LGM) and double low mustard (DLM) strains of *B. juncea* var. Varuna

Characteristics/ Strains	LEM	LGM	DLM	Varuna*
Plant height (cm)	195-205	170-197	198-242	190-200
Days to maturity	135-140	132-140	145-152	140
Seed yield (g/plant)	24-29	14-19	15-20	25-32
Oleic acid (%)	30-44	12-15	35-44	12.8
Linolenic acid (%)	28-31	17-24	43-48	16.9
Linolenic acid (%)	15-22	11-13	6-10	18.4
Erucic acid (%)	0-1.5	39-44	0.0	42.6
Glucosinolate (µm/g oil free meal)	127	9-25	10-27	163

*National check variety *B. juncea* var. Varuna

Transfer of low glucosinolate

The glucosinolate content in the F₃ seeds of the cross *B. juncea* var. Varuna × BJ-1058 ranged from 24-128 µm and in the reciprocal cross BJ-1058 × Varuna ranged from 25-130 µm/g oil free meal. The BC₁F₃ seeds of the cross (Varuna × BJ-1058) × Varuna had 81-176 µm glucosinolate/g oil free meal, and thus no plant having glucosinolate less than 30 µm/g oil free meal could be identified in the backcross progeny. From about 500 plants analyzed, only 1 plant from the *B. juncea* var. Varuna × BJ-1058 and only 2 plants from the reciprocal cross BJ- 1058 × Varuna were identified having less than 30 µm glucosinolate. The F₄ seeds from the single plant progenies of these low glucosinolate plants segregated to synthesize glucosinolate in the range of 40-70 µm in the forward cross (Varuna × BJ-1058) and again no plant having glucosinolates less than 30 µm/g oil free meal could be identified. The F₄ seeds from the single plant progenies of the low glucosinolate selections of the reciprocal cross BJ-1058 × Varuna synthesized glucosinolates

in the range of 10-84 μm and ten plants having less than 30 μm glucosinolate/g oil free meal were identified. In the single plant progenies of these low glucosinolate selections, some of the plants again segregated to synthesize more than 30 μm glucosinolate during F₅ and F₆ generations. Selections were made for the plant progenies where most of the plants synthesized < 30 μm glucosinolate, and the plants having low glucosinolate (i.e. 18-22 μm) were used for progeny advancement. Out of the 15 plant progenies forwarded from these low glucosinolate selections, only two showed stability where all plants synthesized < 30 μm glucosinolate/g oil free meal.

Transfer of double low characteristics

The glucosinolate content in the F₃ OP seeds of the three way cross, *B. juncea* var. (Varuna $\times$ Zem-1) $\times$ BJ-1058, made for transfer of double low characteristics, ranged from 16-134 μm /g oil free meal. Out of about 450 plants analyzed, only one plant was identified having low glucosinolate. The glucosinolate content in the F₄ seeds of the single plant progenies derived from the selected plant ranged from 19-55 μm . The self seeds of the plants synthesizing < 30 μm glucosinolate were analyzed for their fatty acid content, and only four plant progenies were identified having double low characteristics i.e. < 2 per cent erucic acid in the seed oil and < 30 μm glucosinolate/g oil free meal. Out of the twenty-five double low single plant progenies advanced from these selections, many of them segregated for their glucosinolate content, synthesizing glucosinolates upto 73 μm /g oil free meal. Only three plant progenies remained stable for their quality characteristics in F₆ seeds, synthesizing 15-22 μm glucosinolate/g oil free meal and 0-2 per cent erucic acid.

The breeding for low erucic acid and low glucosinolate *B. juncea* becomes difficult due to

the non-availability of desirable donor sources as well as the complicated genetic factors. The erucic acid content is under genetic control determined by the growing embryo (Harvey and Downey, 1964; Kondra and Stefansson, 1965). It is reported to be under the control of two genes with additive effects (Dorrell and Downey, 1964; Siebel and Pauls, 1989). Therefore, each seed from the same plant contains different genetic background resulting in seed to seed variation in the levels of erucic acid, and half seed technique, as applied in present study, is preferred for selection of zero erucic acid plants in the segregating population (Downey and Harvey, 1963). The high glucosinolate content is dominant over low glucosinolate types and are governed by at least three partially recessive genes (Kondra and Stefansson, 1970; Uzunova *et al.*, 1995). Both erucic acid and glucosinolates are inherited independently and a large number of segregating plant populations needs to be screened for several generations to select plants having desired quality parameters. Therefore, poor recovery of low glucosinolate plants in the present study is due to the involvement of several recessive genes resulting in segregation for high glucosinolate types even upto F₆ generation. Similar to our observations Malode *et al.* (1995) in their efforts to transfer double low characteristic in Indian *B. juncea* cv. Pusa Bold have also reported segregation for high erucic acid and high glucosinolate upto F₅ generations.

The international efforts for developing rapeseed mustard strains with single low/double low characteristics were initiated during early fifties. Stefansson *et al.* (1961) developed the first zero erucic acid strains of *B. napus* in 1961. This was followed by the development of zero erucic acid strains of *B. campestris* (Downey, 1964). In similar studies, Kirk and Oram (1981) obtained low erucic acid strains of *B. juncea* by screening for low erucic acid in the F₂ progeny by half

seed technique. Alonso *et al.* (1991) have obtained the low erucic acid genotypes of Ethiopian mustard through continuous pedigree selection of plants with reduced erucic acid. Simultaneously, the efforts towards development of double low cultivars led to the release of world's first double low *B. napus* cv. Tower by Stefansson in 1974 and of world's first double low *B. campestris* cv. Candle by Downey in 1977 (Bell, 1982). During recent years, the low erucic acid/low glucosinolate/double low strains of many brassica species and its wide allies have also been reported from several countries (Scarath, 1995; Rakow, 1995; Potts *et al.*, 1999; Oram *et al.*, 1999).

Love *et al.* (1990) developed the low glucosinolate *B. juncea* through interspecific hybridization of *B. rapa* and *B. juncea*, and as a result produced the *B. juncea* low glucosinolate line BJ-1058 (used as pollen source in the present work). This first low glucosinolate line of *B. juncea* had poor fertility, high erucic acid and low oil content, and until the initiation of the present study (Rabi 1992-93) was the only known source of low glucosinolate *B. juncea* internationally. Using the low glucosinolate source Rakow *et al.* (1995) created improved lines by crossing with high yielding cultivars and further improved its fatty acids profile to bring it at par with canola quality standards (Potts *et al.* 1999). In Australia, a research programme was undertaken over a period of 25 years involving somaclonal variation, repeated mutagenesis and crossing between late maturing zero erucic acid cultivars with early maturing accessions from India and China. This led to the development of early flowering, canola quality *B. juncea* germplasm (Oram *et al.*, 1999). Field trials are underway to test the yield potential of these canola quality *B. juncea* and efforts are being made for their acceptance for commercialization.

The Indian efforts towards this goal were initiated only about two decades ago and initially

it remained confined to the testing of various exotic quality strains for their yielding capabilities at various locations. Most of them were late in maturity having poor seed set and were not found suitable to grow under Indian agroclimatic conditions (AICRP R&M, 1994). Recently, good progress has been made towards development of low erucic acid *B. juncea* (Agnihotri and Kaushik, 1998; Banga *et al.*, 1998) and the double low *B. napus* (Agnihotri and Kaushik, 1999). A double low *B. napus* hybrid (Hyola-401) developed by a private Australian seed company has been notified by ICAR (AICRP R&M, 1998). The low erucic acid strains of *B. juncea* and double low strains of *B. napus* developed at TERI have been registered by NBPGR-ICAR (Singh, 1998, 1999). Efforts are underway towards development of low glucosinolate and double low *B. juncea*.

The present work is an effort in this direction to introduce quality characteristics in *B. juncea*. The important agronomical and quality characteristics of the low erucic acid (LEM), low glucosinolate (LGM) and double low (DLM) mustard strains developed is given in Table 1. The erucic acid content in the LEM and DLM is reduced to the required international standard (< 2%) as compared to Varuna (44%), with corresponding increase in oleic acid content (30-44%) against only 12 per cent in Varuna. The LEM lines are being tested under AICRP multilocation trials. The glucosinolate content is reduced considerably (< 30 μ m) in LGM and DLM as compared to Varuna (163 μ m) and is within the canola quality range. However, there is a need to select plants with lower levels of linolenic acid content from the present 6-22 per cent to < 5 per cent as desired for better oil stability (Scarath *et al.* 1999). There is a scope to reduce the plant height, days to flowering/maturity and seed yield by crossing with high yielding cultivars with desired attributes. Further work is in progress in this direction.

The complete change over to canola quality cultivars in the major rapeseed mustard growing Asian countries, India and China, may take at least a decade (Downey and Chopra, 1996). Once achieved, the farmers and consumers will be able to derive the benefit through proper planning and initiatives for promotion of healthier oil for human consumption at a premium price and through high price of de-oiled cake. The work reported is a stepping stone in this direction providing valuable gene pool for low erucic acid, low glucosinolate and double low characteristics in Indian *B. juncea*. These can be utilized for developing high yielding cultivars with good agronomic attributes and superior nutritional quality.

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STUDY ON VARIABILITY AND CORRELATIONS IN INDIAN RAPE (*Brassica campestris* L.) GERMPLASM

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Comparative pattern of variability and correlations was investigated in the two ecotypes of Indian rape, *Brassica campestris* L., viz., brown *sarson* (90 accessions) and yellow *sarson* (60 accessions). In both the ecotypes, viz., brown *sarson* (Group I) and yellow *sarson* (Group II), the oil content and the days to maturity exhibited the lowest variation whereas the primary branches/plant and the secondary branches per plant had the highest. Except for the siliqua on main shoot in brown *sarson* and the seeds per siliqua in yellow *sarson*, the pattern of variation was similar in both the Groups. The correlations were, however, variable in both the Groups. A consistent trend of relationship was observed in both the Groups for the plant height with the main shoot length ($r=0.565^{***} - 0.568^{**}$) and the siliqua on main shoot ($r=0.344^{**} - 0.679^{**}$) and similarly, the siliquae on the main shoot with main shoot length ($r=0.464^{**} - 0.471^{**}$) and the primary branches per plant ($r=0.386^{**} - 0.497^{**}$). The rest of the 1000-seed weight in Group II, the other traits seemed to be independent of the days to maturity, hence early types with good agronomic base could be developed.

Key words : Indian rape, *Brassica campestris* L., correlations, variability, agro-morphological traits

The major oleiferous *Brassica* grown in India are Indian mustard (*Brassica juncea* [L.] Czern & Coss.) and then three ecotypes of *B. campestris* L. viz., brown *sarson*, yellow *sarson* and *toria*. Among the three ecotypes of *B. campestris*, brown *sarson* appears to be the oldest. *Toria* and yellow *sarson* are reported have arisen from selection of a mutant of brown *sarson* for any early maturity type and for the yellowish seed colour, respectively (Singh, 1958; Hinata and Prakash, 1984).

The cultivation of brown *sarson* in the north-western region overlapped to a large extent with Indian mustard. Brown *sarson* is cultivated under rainfed condition and its yield potential is low. Brown *sarson* is rated as susceptible to soil sodicity (Kumar *et al.* 1984). Due to high susceptibility to frost, brown *sarson* once a predominant crop in India, has shrunk in hectareage

and now cultivated only in Himachal Pradesh and Kashmir valley. Nevertheless due to its early maturity and high oil content as compared to *B. juncea*, brown *sarson* fits well in the sugarcane growing areas (Brown *sarson* - Sugarcane cropping system). Yellow *sarson*, has been again making inroads in eastern India especially in West Bengal, Sikkim, Bihar, eastern Uttar Pradesh. Varieties like NDYS 1, Jhumka YS-193-3 and Rajendra *sarson* 1 are very popular. The medium - maturing yellow *sarson* has been reported to replace early duration *toria* owing to high yield and feasibility for sunflower sowing in February/March in the *tarai* region of Uttar Pradesh. However yellow *sarson* is highly susceptible to aphid (*Lipaphis erysimi* Kalt.) It is, therefore, imperative to develop early maturing and high yielding varieties of both brown *sarson* and yellow *sarson* that they escape

from the diseases and pests and fit in multiple cropping system. It could be desirable to systematically evaluate the available genetic resources of these two crops. In the present investigation, comparative variability and pattern of correlations in brown *sarson* and yellow *sarson* were studied.

MATERIALS AND METHODS

One hundred and fifty accessions of two ecotypes of *Brassica campestris* L. namely, brown *sarson* (90) and yellow *sarson* (60), were grown in 2-row plot in augmented design during rabi 1995-96 crop season. The plot length was 5m with a spacing of 30 cm $\times$ 15 cm between rows and between plants in a row, respectively. Forty kg N and 40 kg P₂O₅ per ha were applied at the time of sowing while 40 kg N per ha was top-dressed just after first irrigation (40 days after sowing). Standard agronomic practices were followed and plant protection measures were adopted as and when required. Observations were recorded on five competitive randomly chosen plants. The characters studied were days to maturity, plant height (cm), primary and secondary branches per plant(no.), main shoot length (cm), siliqua on main shoot(no), siliqua length (cm), seeds per siliqua(no.), 1000-seed weight (g) and oil content (%).

Mean values were used to compute coefficients of variability to assess variation in agro-morphological traits in brown *sarson* (Group I); yellow *sarson* (Group II) and pooled (Group III). Simple correlation coefficients among the different agro-morphological traits were estimated following standard statistical methods (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

1. Variability

The coefficients of variation (CV) indicated in both the groups, primary and secondary

branches per plant varied the most (Table 1). In the yellow *sarson* (Group II), primary branches per plant showed higher variation while in brown *sarson* (Group I) secondary branches per plant showed higher variability. The magnitude of CV for seeds per siliqua was higher in Group II while in Group I, it was for siliquae on main shoot (Table 1).

The variability was the lowest for oil content and days to maturity in both the Groups. There was no appreciable difference in the extent of variation for days to maturity, plant height, main shoot length, siliqua length and 100-seed weight in Group I and Group II. Except for seeds per siliqua (Group II) and siliquae on main shoot (Group I), the pattern of variation was, by and large similar in both the Groups. Pooled analysis of variability (Group III) revealed that secondary and primary branches per plant, siliquae on main shoot, seeds/siliqua, 1000- seed weight and main shoot length exhibited substantial variation.

2. Correlation

As is evident from Table 2, the interrelationships among various agro-morphological traits showed that plant height was positively and significantly correlated with main shoot length and siliquae on main shoot in both the Groups. Similar results were also reported by Kumar and Yadava (1978a) and Yadava *et al.* (1988). Siliqua on the main shoot also had positive and significant association with primary branches per plant and main shoot length. The pattern of relationship for these traits in Group I and Group II was also reflected in the pooled analysis. Kumar and Yadava (1978a) also observed a high positive genotypic association between siliquae on main shoot with primary branches per plant in Indian rape.

In brown *sarson* (Group I) and yellow (Group II), seeds per siliqua was negatively and significantly associated with secondary branches per plant. In

Table 1. Comparative variability in agro-morphological traits among three groups of *Brassica campestris* L

Character	Coefficient of variability (%)		
	Group I (Brown <i>sarson</i>)	Group II (Yellow <i>sarson</i>)	Group III (Pooled)
Days to maturity	3.7	4.1	5.1
Plant height	8.5	8.4	8.7
Primary branches/plants	27.0	35.9	30.1
Secondary branches/plant	49.1	38.4	48.1
Main shoot length	12.5	12.0	12.6
Siliquae on main shoot	18.9	11.7	16.4
Siliqua length	10.6	9.2	10.0
Seeds/siliqua	10.2	25.0	22.6
1000-seed weight	11.5	13.2	13.7
Oil content	2.7	2.9	2.9

Group I, the relationship of secondary branches per plant with plant height was negatively significant ($r=-0.302^{**}$) whereas primary branches per plant was positively associated with secondary branches per plant ($r=0.300^{**}$). Seeds per siliqua was positively and significantly associated with siliqua length ($r=0.485^{**}$) only in Group I. When the brown *sarson* and yellow *sarson* accessions were combined (Group III), the interrelationship of days to maturity was significantly positive with plant height ($r=0.245^{**}$), secondary branches per plant ($r=0.285^{**}$), main shoot length ($r=0.218^{**}$), seeds per siliqua ($r=0.201^{*}$) and 1000-seed weight ($r=0.3444^{**}$). However, secondary branches per plant had negative association with siliquae on main shoot, and its relationship with 1000-seed weight was positive (Table 2).

The relationship between oil content and main shoot length was positive ($r=0.210^{*}$), whereas, it had negative relationship with siliqua length ($r=-0.167^{*}$) in the pooled analysis.

Days to maturity and plant height showed negative and significant association with seeds per siliqua but relationship of days to maturity with 1000-seed weight was positive ($r=0.293$) only in yellow *sarson*. Plant height exhibited positively significant association with primary branches per plant ($r=0.352^{**}$).

The relationship of seeds per siliqua was positive ($r=0.283^{*}$) with primary branches per plant. However Kumar and Yadava (1978b) reported high negative genotypic correlation between these two traits. The associations of seeds per siliqua with main shoot length and 1000-seed weight were negatively significant in Group II only (Table 2). In this Group (yellow *sarson*), oil content was positively and significantly related with main shoot length and siliquae on main shoot. However, interrelationship of oil content with siliqua length was negative and significant ($r=-0.385^{**}$).

The results suggest variable association in the two ecotypes : brown *sarson* and yellow *sarson*; hence group- specific characters need attention in the selection programme. Except for 1000-seed weight in Group II (yellow *sarson*), the other traits appeared to be independent of days to maturity, hence early types with good agronomic base could be developed.

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Table 2. Correlations coefficients between agro-morphological traits in three groups of *Brassica campestris*

Character	Group	Days to maturity	Plant height	Primary branches/plant	Secondary branches/plant	Main shoot length	Siliquae on main shoot	Siliquea length	Seeds/siliquea	1000-seed weight
Plant height	I	-0.026								
	II	-0.123								
	III	0.245**								
Primary branches/plant	I	-0.038	0.052							
	II	-0.210	0.352**							
	III	-0.117	0.054							
Secondary branches/plant	I	0.171	-0.302**	0.300**						
	II	0.220	-0.048	-0.204						
	III	0.285**	0.061	0.025						
Main shoot length	I	0.156	0.568**	-0.135	-0.098					
	II	-0.095	0.565**	0.097	0.071					
	III	0.218**	0.615**	0.005	0.101					
Siliquae on main shoot	I	0.054	0.679**	0.386**	-0.195	0.471**				
	II	-0.165	0.344**	0.497**	-0.190	0.464**				
	III	-0.005	0.533**	0.416**	-0.212**	0.438**				
Siliquea length	I	-0.067	-0.115	-0.048	-0.058	0.003	-0.182			
	II	0.109	-0.049	0.018	0.240	-0.137	0.095			
	III	0.076	-0.072	0.023	0.080	0.035	-0.105			
Seeds/siliquea	I	0.033	0.090	-0.085	-0.288**	0.070	0.128	0.485**		
	II	-0.329**	-0.381**	0.283*	-0.461**	-0.423**	0.041	-0.026		
	III	0.201*	0.006	0.130	-0.116	0.031	0.064	0.154		
1000-seed weight	I	-0.162	-0.180	0.026	0.044	-0.038	0.074	0.108	-0.162	
	II	0.293*	0.028	-0.144	0.152	-0.072	-0.218	-0.002	-0.331**	
	III	0.344**	0.096	-0.074	0.236**	0.118	-0.068	0.093	0.035	
Oil content	I	0.033	0.010	-0.076	-0.111	0.003	-0.079	-0.071	-0.013	0.007
	II	-0.217	-0.112	-0.007	0.092	0.267*	0.267*	-0.385**	-0.139	-0.158
	III	0.114	0.103	-0.047	0.041	0.210*	0.027	-0.167*	0.079	0.074

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CORRELATION AND PATH COEFFICIENT STUDIES OVER ENVIRONMENTS IN RAMIE (*Boehmeria nivea* L. GAUD.)

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Forty ramie genotypes were raised in a randomized block design with three replications considering three dates of cuttings as three environments to study the correlation and path coefficients among nine morphological traits and yield attributes. The correlation studies revealed that every characters showed a highly significant positive correlation with fibre yield and among themselves both at phenotypic and genotypic levels. The path coefficient analysis at genotypic level revealed that number of effective canes had the maximum positive direct effects on fibre yield while the maximum negative direct effect was produced by fresh weight of plant.

Key words : Ramie, *Boehmeria nivea*, correlation, fibre yield, path coefficient

Ramie (*Boehmeria nivea* L. Gaud.) is a shrub belonging to the family *Urticaceae* which is considered as the strongest among all the natural fibres. In ramie, the fibre yield is influenced by a number of yield attributing traits. Therefore, information regarding the association between different yield attributes and also with fibre yield could be very useful for improvement of fibre yield. But the correlation between two characters alone cannot reveal the cause and effect relationship. Separating the correlation coefficients of yield components into direct and indirect effects can be used to understand the exact association. The present investigation was, therefore, undertaken to estimate the genotypic and phenotypic correlations and their direct and indirect effects on fibre yield.

MATERIALS AND METHODS

Forty indigenous and exotic ramie genotypes collected from Ramie Research Station (ICAR), Sorbhog, Assam and some ramie growing pockets

of Assam were evaluated in a randomized block design with three replications maintaining a spacing of 45 cm × 60 cm during 1995-97 in the Experimental Farm of the Department of Plant Breeding and Genetics, Assam Agricultural University, Jorhat. At the time of land preparation, farm yard manure @ 7 tonnes per hectare was applied and when the crop was about two months old a fertilizer mixture of N, P₂O₅ and K₂O @ 20:10:10 kg/ha was applied. The canes were harvested periodically at three dates of cuttings (3 environments) for extraction of fibre. After each harvest, a fertilizer mixture of N, P₂O₅ and K₂O @ 30:15:15 kg/ha was applied for better growth of the plants. Data were recorded on nine morphological and yield attributing traits, viz., plant height (cm), number of effective canes, number of leaves, leaf area (cm²), basal stem diameter (cm), fresh weight of plant (g), fresh weight of cane (g), fresh weight of fibre (g) and dry weight of fibre (g). Mean data for each genotype in each replication for individual traits were utilized to estimate the genotypic and

phenotypic correlation coefficients and their direct and indirect effects. Correlation and path analysis were worked out by as per model given by Panse and Sukhatme (1957) and Dewey and Lu (1959).

RESULTS AND DISCUSSION

The phenotypic and genotypic correlation coefficients among yield and yield components are presented in Table 1. All the characters showed a highly significant and positive correlation with fibre yield per plant and among themselves. Further, the genotypic associations were higher than the corresponding associations at phenotypic level. Gupta (1977) also reported significant positive association of fibre yield and other yield components both at genotypic and phenotypic levels in white jute. Genotypic correlation chiefly results from linkage, pleiotropic action of genes and effect of selection; they acted either individually or jointly. It is, therefore, necessary

to have precise information to choose appropriate yield contributing characters in improvement programme.

The genotypic correlation were further partitioned into direct and indirect effects to establish the cause and effect relationship among yield and its component characters. The results of path analysis at genotypic level are presented in Table 2. The path coefficient analysis indicated that the number of effective canes (+ 0.75) had the maximum positive direct effect on fibre yield per plant followed by number of leaves (+ 0.43), fresh weight of plant (+ 0.20) and basal stem diameter (+ 0.19). Thus significant positive genetic correlation coefficients observed for these characters with fibre yield could be explained mostly due to their influence on fibre yield. These characters deserve topmost consideration in selection programme for improvement of fibre yield. Roy (1984) reported that number of leaves, fresh

Table 1. Correlation co-efficients at genotypic (r_G) and phenotypic (r_P) levels among fibre yield and other yield attributes over three environments (three dates of cuttings)

Characters	Characters								
	Correlation Co-efficient	Number of effective	Number of leaves	Fresh weight of plant (g)	Fresh weight of cane (g)	Basal stem diameter (cm)	Fresh weight of fibre (g)	Leaf area (cm ²)	Dry weight of fibre (g)
Plant height (cm)	r_G	0.84**	0.71**	0.82**	0.80**	0.79**	0.68**	0.85**	0.79**
	r_P	0.75**	0.62**	0.77**	0.76**	0.64**	0.63**	0.82**	0.70**
Number of effective canes	r_G		0.76**	0.84**	0.79**	0.90**	0.94**	0.80**	0.94**
	r_P		0.64**	0.74**	0.72**	0.71**	0.78**	0.72**	0.80**
Number of leaves	r_G			0.84**	0.85**	0.71**	0.81**	0.89**	0.81**
	r_P			0.75**	0.77**	0.60**	0.62**	0.84**	0.69**
Fresh weight of plant (g)	r_G				0.93**	0.86**	0.77**	0.78**	0.81**
	r_P				0.90**	0.72**	0.70**	0.75**	0.74**
Fresh weight of cane (g)	r_G					0.80**	0.70**	0.80**	0.74**
	r_P					0.68**	0.62**	0.77**	0.68**
Basal stem diameter (cm)	r_G						0.92**	0.73**	0.86**
	r_P						0.74**	0.62**	0.69**
Fresh weight of fibre (g)	r_G							0.70**	0.97**
	r_P							0.63**	0.92**
Leaf area (cm ²)	r_G								0.81**
	r_P								0.73**

**Significant at $P = 0.01$

Table 2. Path analysis of the total correlation observed at genotypic level between fibre yield per plant and other related parameters over three environments (three dates of cuttings)

Characters	Plant height (cm)	Number of effective canes	Number of leaves	Fresh weight of plant (g)	Fresh weight of cane (g)	Basal stem diameter (cm)	Fresh weight of fibre (g)	Leaf area (cm ²)
Plant height (cm)	0.004	0.003	0.003	0.003	0.003	0.003	0.003	0.003
Number of effective canes	0.630	0.750	0.570	0.630	0.600	0.670	0.700	0.600
Number of leaves	0.300	0.340	0.430	0.360	0.370	0.300	0.350	0.380
Fresh weight of plant (g)	0.160	0.160	0.170	0.200	0.180	0.170	0.150	0.150
Fresh weight of cane (g)	-0.420	-0.140	-0.440	-0.490	-0.520	-0.420	-0.350	-0.420
Basal stem diameter (cm)	0.150	0.170	0.130	0.160	0.150	0.190	0.170	0.140
Fresh weight of fibre (g)	-0.04	-0.060	-0.050	-0.050	-0.040	-0.060	-0.060	-0.040
Leaf area (cm ²)	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003
Genotypic correlation coefficient	0.790**	0.940**	0.810**	0.820**	0.740**	0.860**	0.970**	0.820**

Residual effect ± 0.25 ; **Significant at $P = 0.01$

weight of stem, basal stem diameter had high positive direct effect on fibre yield. Singh and Tuteja (1989) also reported that fresh weight of plant had high positive direct effect on fibre yield. Besides the high direct positive effect of number of effective canes on fibre yield, the remaining traits contributed high positive effect of number effective canes on fibre yield, the remaining traits contributed high positive indirect effects via this trait. The positive direct effect of number of leaves was high and the remaining traits also exerted high positive indirect effect on fibre yield via this trait. Therefore, it revealed from the study that number of effective canes, number of leaves, fresh weight of plant, basal stem diameter and fresh weight of cane are the most important traits to improve the fibre yield in ramie.

As regards the residual effect it was seen that apart from the variables under study there could be certain factors influencing the fibre yield

as was evident from the estimates of residual effect of ± 0.25 . In this context characters like top stem diameter, number of nodes, internode length, number of roots, root length etc. could be incorporated in future studies.

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CLASSIFICATION OF URIDBEAN GERMPLASM FROM DIVERSITY ZONES OF UTTAR PRADESH

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The landraces in Urid bean (*Vigna mungo* L.) were collected from diversity rich zones in Uttar Pradesh, India. The collections were characterized for visual traits and quantitative characters. The ordination of genotypes were done by principal component analysis. The classification gave 13 clusters. Many resistant genotypes for viral diseases were identified. The genetic donors for yield, pod and flowering traits were isolated along with green seeded erect types which are not found frequently.

Key words : Uridbean, *Vigna mungo* L., landraces, classification

Uridbean [*Vigna mungo* (L.) Hepper] is an important pulse crop of Indian sub-continent. India being one of the important centre of diversity, a thrust for germplasm collection, evaluation and conservation is a desired necessity to keep pace with increasing population. Keeping this in view, explorations were conducted in the districts of Uttar Pradesh namely Hardoi, Barabanki, Bareilly, Sitapur and eight districts in Kumaon and Garhwal which were reported to be rich in diversity for local types in this crops (Paroda and Arora, 1991). For estimation of diversity within the germplasm, the classification of germplasm accessions into homogenous groups is utmost desirable practice using multivariate parameters instead of using univariate methods. It was presumed that the genotypes originated from distantly separated regions of the world are likely to be different in their genetic make up. However, several scientists for different crop species have supported no parallelism in geographical distribution and genetic diversity (Malhotra and Singh, 1971).

A number of classificatory approaches based on multivariate analysis have been postulated by several workers. The D^2 statistics has been given by Mahalanobis (1936). In case of germplasm collection, which are characterized in large numbers involving various characters, the use of D^2 becomes very limited and goes beyond practical reach (Arunachalam, 1981). The classificatory approaches like principal component, factor analysis and clustering of genotypes overcome these limitations of D^2 statistics (Beale, 1969). In principal component analysis, the observable variates are presented as a function of smaller number of latent vectors, so that few orthogonal variates are obtained (Morrison, 1976). The cluster analysis is utilized for further classification. The collected 150 accessions of uridbean were subjected to such classification in the present study.

MATERIAL AND METHODS

The 150 uridbean accession collected from diversity zones of Uttar Pradesh were sown in the month of July at Crop Research Station, Pantnagar in augmented design with four checks

namely Narendra Urid-1, Pant Urid-35, Type-9, and Pant Urid-19 after every 10 plots of new accessions. Each plot of accession as well as checks consisted of 2 rows of 4m length. The row spacing was 30 cm and plant spacing was kept 10 cm. All accessions were assigned in 15 blocks with 4 repeated checks in every block. Observations for characters such as, plant height (cm), days to 50 per cent flowering, days to maturity, pods per plant, pod length (cm), seeds per pod, 100 seed weight (g) and yield (kg/ha) were subjected to statistical analysis. The analysis of variance was performed in augmented design using by Federer and Raghav Rao (1975) and Peterson (1985). The genotypic means were adjusted for the block effects as measured by the check plots. The total number of block were determined by relationship

$$b > \left[\frac{10}{c-1} + 1 \right]$$

where, b = number of blocks
c = number of checks

The adjustment factor $r_j = (1/C) (B_j - M) =$ Mean of j^{th} block minus grand mean. The adjusted yields were calculated by subtracting r_j from actual observations.

$$y_i = y_{ij} - r_j$$

where, Y_{ij} = yield of i^{th} variety occurring in j^{th} block.

This analysis gave adjusted values for all characters in each accessions. Further classificatory analysis was done on these adjusted values of variables. For extracting the principal components, correlation matrix was obtained by adjusted means of variable as matrix following Mardia *et al.* (1980). The matrix of r non zero eigen values was utilized to extract r principal components. Thus from a matrix of 6 non-zero eigen values, 6 principal components (PCP) were extracted.

Here the 1st PCP represented largest variance of random linear combination of variables represented in data matrix. The other PCPs were orthogonal axis of 1st PCP. The measure of degree of fit or fraction of total variance explained by 6 principal components were obtained as fraction of non zero eigen values and total R eigen values.

The genetic divergence among genotypes was studied using method of non hierarchical euclidian, cluster analysis (Beale, 1969; Spark, 1973). The PCPs obtained from original variables were utilized for this analysis. The assumption for this method was that the euclidian distances 'D' separating 'n' points in a 'P' dimensional space are proportional to the dissimilarities between the objects and secondly, that no object can belong simultaneously to two clusters.

RESULTS AND DISCUSSION

The analysis of variance performed for augmented designs revealed sufficient differences among checks. The results for mean and range in various characters has been given in Table 1. The range of characters is indicative of high amount of variability as the plant height ranged from 125-184 cm and maturity ranged from 58 days to 116 days. The pods per plant showed tremendous variability with minimum of 9.9 up to 116.6 pods. The pod length varied from 2.9 to 7.12 cm and seed weight varied from 1.32 to 4.72 g. The maximum yield was obtained in accession ShU 96133 which was a local collection from district Nainital. The earliest accession in flowering and maturity was ShU 9547 which had different foliage and pod characters. Accession ShU 9534, a collection from district Hardoi had the highest number of pods and found resistant to both yellow mosaic and leaf crinkle virus.

The evaluation data obtained as adjusted means for various characters were converted to

single index of similarity in the form of principal component. The values of eigen vectors, roots and variation explained has been given in Table 2. The maximum value of eigen roots 2.89 was obtained by 1st eigen vector followed by 1.85, 1.08, 0.833, 0.69, 0.42, 0.18, 0.33 by other corresponding seven vectors. The different vectors associated with various characters have shown positive and negative values as contribution obtained for vectors. The contribution of positive and negative values is based on relative proportion of multivariates in the formation of orthogonal vectors as the observable variates are presented as a function of smaller number of latent vectors so that few orthogonal variates are obtained (Morrison, 1976).

The maximum variation of 36.13 per cent was explained by 1st vector and rest of the variation 23.20, 13.54, 10.42, 8.63, 5.36, 2.27 and 0.41 were explained by other seven vectors. The maximum variation contributed for first vector is from characters plant height, pods per plant and yield kg/ha. The first six-principal components explained 97.31 per cent variation which were utilized for clustering purpose.

The cluster analysis grouped 154 accessions into 13 clusters which was found appropriate as determined by F test. The non-hierarchical clustering procedures followed, allows solution to large data problems because it is not necessary to calculate and store the similarity matrix every time. The inter and intra cluster distance between and within clusters have been given in Table 3.

The maximum intra cluster distance 1.976 was found in cluster 8 and minimum in cluster 6. This distance is indicative of relative divergence among similar genotypes within a group. The maximum inter cluster distance was between cluster 13 and 10. These clusters had accessions collected from various different localities. The arrangement of accessions in between clusters was found independent of their locality of collections indicating that pattern of diversity in uridbean is not location specific.

The cluster means as depicted in Fig. 2 revealed that within clusters, the accessions with distinct characters, clustered together making a particular cluster distinct. The tallest accessions were recorded in cluster 10 which had the highest mean of 139.27 cm, cluster 8 had early flowering

Table 1. Mean and range of various quantitative characters in uridbean germplasm

Particulars	Characters							
	Plant height (cm)	Days to 50% flowering	Days to maturity	Pods/plant	Pod length (cm)	Seed/pod	100 seed weight (g)	Yield (kg/ha)
Accessions	90.83 (125.5-183.8)	54.93 (18.4-79.7)	86.37 (58-116)	30.20 (9.9-116.6)	4.22 (2.90-7.12)	6.67 (3.42-7.61)	3.24 (1.32-4.72)	1057 (709-2839)
Check 1 (Narendra Urid 1)	191.5	42.93	75.53	44.87	4.567	6.507	3.175	2301
Check 2 (PU-35)	112.3	42.73	74.67	42.93	4.567	6.780	3.039	1602
Check 3 (T-9)	93.87	43.20	76.00	35.53	4.380	6.820	3.197	1371
Check-4 (PU-19)	101.6	43.93	75.00	39.07	4.300	6.593	2.984	1709
CV %	16.13	3.773	4.164	26.80	5.263	6.321	8.858	18.63

(Range in parenthesis)

Table 2. Showing eigen vectors, eigen roots and associated variance for different components in urid germplasm

Particulars	Characters							
	Plant height (cm)	Days to 50% flowering	Days to maturity	Pods/plant	Pod length (cm)	Seed/pod	100 seed weight (g)	Yield (kg/ha)
Plant height (cm)	0.38	0.40	-0.14	-0.23	-0.16	0.51	0.56	-0.027
Days to 50% flowering	-0.35	0.57	-0.039	0.050	0.19	-0.026	-0.048	0.71
Days to maturity	-0.33	0.58	-0.02	0.07	0.21	-0.032	-0.09	-0.69
Pods/plant	0.42	0.28	0.10	0.06	-0.14	-0.80	0.23	0.002
Pod length (cm)	0.35	-0.08	-0.21	-0.30	0.84	-0.065	-0.064	0.01
Seeds/pod	0.15	-0.016	-0.68	0.70	0.01	0.04	-0.003	0.003
100 seed weight (g)	0.22	0.009	0.66	0.57	0.31	0.23	0.13	0.03
Yield (kg/ha)	0.48	0.28	0.06	-0.04	-0.22	0.18	-0.76	0.03
Eigen roots	2.89	1.85	1.08	0.833	0.69	0.42	0.18	0.033

Table 3. Average inter and intra cluster distances in uridbean germplasm

Cluster No.	1	2	3	4	5	6	7	8	9	10	11	12	13
1.	(1.106)												
2.	1.791	(1.212)											
3.	1.687	1.550	(1.239)										
4.	3.379	3.085	2.541	(1.566)									
5.	2.283	2.601	2.467	1.939	(1.023)								
6.	3.156	2.601	2.966	3.995	3.143	(1.030)							
7.	2.742	2.238	3.057	3.175	1.916	2.158	(1.340)						
8.	5.493	4.010	4.716	4.068	4.962	5.367	4.500	(1.976)					
9.	4.402	3.976	3.946	4.436	4.220	4.635	4.506	6.166	(1.412)				
10.	3.140	3.117	2.409	2.545	2.261	2.389	2.906	5.582	4.014	(1.307)			
11.	2.880	2.249	2.350	3.154	2.529	1.443	2.150	5.037	3.312	1.654	(1.078)		
12.	2.487	2.376	2.902	3.011	1.865	3.562	2.102	4.883	3.160	3.333	2.683	(1.193)	
13.	12.409	12.409	12.303	12.465	12.353	12.302	12.398	13.137	12.876	12.469	12.347	12.000	(0.000)

(Values in parenthesis are intra cluster distance)

and maturity types. The maximum number of pods with mean value of 44 per plant were obtained in cluster 13 which is a single entry

cluster with accession ShU-9641 collected from Shergarh in district Bareilly. This cluster also had maximum number of seeds per pod. The entry

was typically distinct and exclusive. This cluster was in maximum diverse end (Fig. 1).

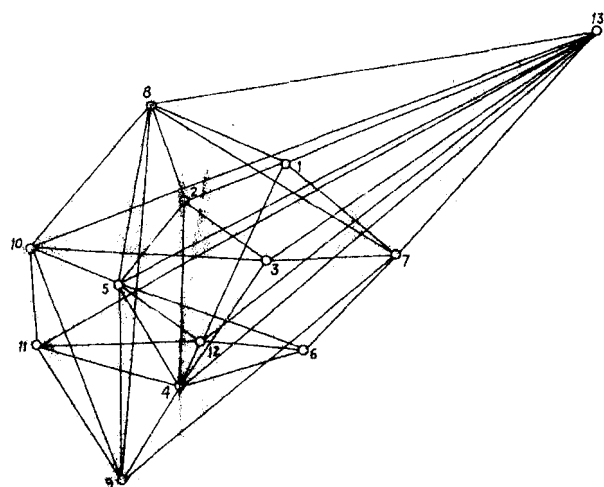


Fig. 1. Cluster diagram showing relative inter cluster distances among uridbean germplasm

Table 4. Identified genetic donors for various characters in uridbean germplasm

Character	Entry Name
1. Plant height (cm)	ShU 9511, ShU 9512, ShU 9537, ShU 9539, ShU 9606
2. Days to 50% flowering	ShU 9636, ShU 9603, ShU 96104
3. Days to maturity	ShU 9636, ShU 9603, ShU 96104
4. Pods/Plant	ShU 9636, ShU 9603, ShU 96104
5. Pod Length (cm)	ShU 96104, ShU 9603, ShU 9634
6. Seed/Pod	ShU 9641
7. 100 Seed Weight (g)	ShU 9536, ShU 9603, ShU 96104

The presentation in the Fig. 2 allowed convenient selection of superior clusters for different traits and their accessions within these clusters. The promising accessions identified as genetic donors have been given in Table 4, which can be utilized in breeding programmes.

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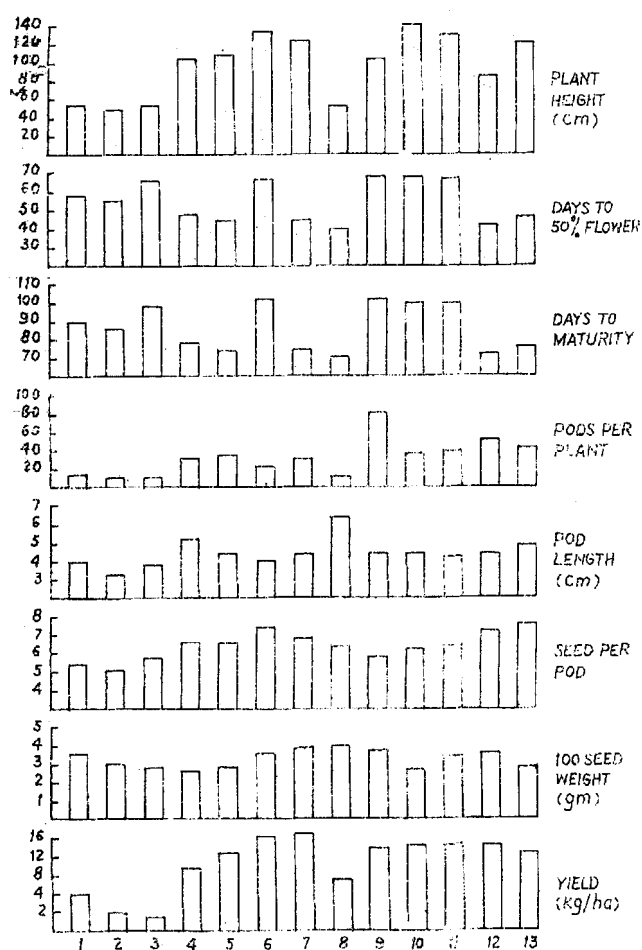


Fig. 2. Cluster means of different characters in uridbean germplasm

providing finance to conduct this work.

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MICROPROPAGATION OF *Commiphora wightii* (ARNOTT) BHANDARI — A THREATENED MEDICINAL PLANT OF SEMI-ARID REGION

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A simple and efficient micropropagation method is developed for *Commiphora wightii* from the cotyledonary nodal segments of twenty one-day-old *in vitro* grown seedlings. Multiple shoots were initiated on MS medium containing IAA 0.1 mg l⁻¹, BA 1.5 mg l⁻¹ and additives consisting of 50 mg l⁻¹ ascorbic acid, 25 mg l⁻¹ each of citric acid, arginine and adenine sulphate. The isolated shoots were multiplied on MS medium containing IAA 0.1 mg l⁻¹, BA 1.0 mg l⁻¹ and additives as in the initiation medium. Shoots were rooted on 1/2 strength MS medium containing 0.25 mg l⁻¹ IBA. The rooted plantlets were hardened and transferred to soil.

Key words : *Commiphora wightii*, micropropagation, rooting, hardening

Increasing human activities and wide range exploitation of plants for their useful components caused disturbances in the habitats of plants. This resulted in complete loss of gradual reduction of important germplasm of economically and medicinally important plant species. Emphasis has been given on the conservation of these plant species either by conventional or unconventional methods (Mohamed *et al.*, 1999). Multiplication and conservation of threatened and rare plant species by using biotechnological methods is being done for various species (Arora and Bhojwani, 1989; Anand *et al.*, 1999) and is being utilized for conservation of important plant germplasm for posterity.

Commiphora wightii (Arnott) Bhandari of Burseraceae, is a balsamiferous shrub, which is apomictic in nature (Gupta *et al.*, 1996). Crude and wide range tapping for oleogum resins resulted in the decline of natural population of this plant and is threatened in nature (Jain and Sastry, 1980). Medicinal plants are of great interest to the researchers of plant biotechnology, as most

of the drug industries depend, in part on plants for the production of pharmaceutical compounds (Chand *et al.*, 1997). *C. wightii* is exploited for its products used in indigenous ayurvedic medicine. Its antiasthmatic as well as hypocholesterolaemic properties have been reported (Satyavadi, 1990) and so many commercial products have been marketed. It yields guggul, an important oleogum resin used as incense, fixative and perfumery. Natural propagation by conventional methods is very slow and extremely poor under semi-arid conditions and is not adequate to meet with the increasing demands of this plant. There is an important need to conserve its germplasm and also to ensure sustainable supply of this raw material. Establishment of *in vitro* cultures of *C. wightii* and plantlet regeneration is described in this communication.

MATERIALS AND METHODS

1. Collection and inoculation of seeds

Ripe fruits of *C. wightii*, collected from Kaylana, Rajasthan during the month of April-May

were depulped by keeping the seeds in running tap water and then removing the remaining pulp by rubbing the seeds in a muslin cloth. Seeds were dried and the hard seed coat was removed by treating the seeds with concentrated sulphuric acid for 3-4 minutes. The softened seed coat was removed with a scalpel and needle and the seeds were recovered. Elaborate seed treatment methods were not required for the recovery of viable seeds from the fruits as described by Barve and Mehta (1993). The seeds were surface sterilized with 0.075% (w/v) mercuric chloride solution for four minutes, washed with sterilized distilled water 6-7 times and kept in sterilized distilled water for 20-25 minutes for the seeds to absorb water and then inoculated on to hormone free MS medium (Murashige and Skoog, 1962) for germination.

2. Initiation and multiplication of cultures

From 20-25 days old seedlings, cotyledonary nodal portion, cotyledon, hypocotyl and roots were excised and kept for shoot regeneration in MS and White's (Gamborg *et al.*, 1968) media containing IAA and NAA (0.05, 0.10 and 0.25 mg l^{-1}) along with BA (0.5, 1.0, 1.5, 2.0 and 2.5 mg l^{-1}) and TDZ (0.05, 0.10, 0.15, 0.20 and 0.25 mg l^{-1}). Both the media were adjusted with 50 mg l^{-1} ascorbic acid, 25 mg l^{-1} each of citric acid, arginine and adenine sulphate. The pH of the media were adjusted to 5.7 prior to the addition of agar (0.7% w/v) and sterilized at 120°C for 20 minutes. Cultures were incubated at $27 \pm 2^\circ\text{C}$ and light intensity of $40 \mu\text{E m}^{-2} \text{s}^{-1}$ and photoperiod of 16h/d. The shoots induced from the cotyledonary nodal portion were excised after 14 days and kept horizontally in MS medium containing IAA (0.05, 0.1, 0.25 and 0.50 mg l^{-1}) and BA (0.5, 1.0, 2.5 and 5.0 mg l^{-1}) along with the same additives used for the initiation of shoots.

3. Rooting of shoots, acclimatization and pot transfer of plantlets

The shoots of 3-4 cm length were isolated

from the shoot clump and kept in varying concentrations of MS salts (full MS, 3/4 MS, 1/2 MS and 1/4 MS) along with auxins IAA, NOA and IBA (0.05, 0.10, 0.25 and 0.50 mg l^{-1}). The rooted plantlets were removed from the culture and adhered agar was removed from the plantlets and kept in culture bottles containing autoclaved soilrite moistened with 1/4 MS nutrient salts and was kept in green house at 80 per cent relative humidity. The caps of the bottles were gradually removed after seven days and the plantlets were exposed to outer environment. After one month of hardening, the plantlets were transferred to sandy soil in pots.

All the experiments were repeated at least thrice with ten replicates each and observations were recorded during an interval of 21 days for all the experiments. Data were analyzed statistically by using ANOVA.

RESULTS AND DISCUSSION

1. Initiation and multiplication of cultures

Of the two media tested, maximum growth was observed in MS medium containing IAA 0.1 mg l^{-1} , BA 1.5 mg l^{-1} along with 50 mg l^{-1} of ascorbic acid, 25 mg l^{-1} each of citric acid, arginine and adenine sulphate. Effects of these additives on shoot initiation of various species from the arid region have been reported (Arya and Shekhawat, 1986). Two to three shoots were initiated from cotyledonary nodes during the culture period of 21-25 days (Fig. 1). The data



Fig. 1. Initiation of shoots from the cotyledonary nodal portion of *C. wightii* on MS medium containing IAA 0.1 mg l^{-1} , BA 1.0 mg l^{-1} and additives.

shows IAA, an unstable auxin under light, is more efficient for shoot regeneration than NAA, which is stable under light conditions. The results also shows that cotyledonary nodal explants needed an unstable auxin for a short period of time in order to regenerate shoots, because at low cytokinin levels, the rate of regeneration was more frequent as IAA concentration was increased, but a stable auxin like NAA could suppress shoot regeneration. George (1993) made similar observations for the synergetic effects of auxin and cytokinins. Higher concentrations of BA produced large number of shoots, which were small in size. TDZ at low concentrations induced large number of fasciated and vitrified shoots which senesced during the subculturing period (Table 1). Similar observations

Table 1. Effect of various auxins, cytokinins and TDZ on shoot induction from the cotyledonary nodal segments of *C. wightii* in MS medium containing additives. (Data collected after 21 days)

Medium	Auxin(s) mg l ⁻¹	Cytokinin (s) mg l ⁻¹	Mean shoot number/ explant $\pm$ SE	Mean shoot length (cm) $\pm$ SE
MS (control)	-	-	1.1 $\pm$ 0.31 ^a	1.04 $\pm$ 0.12 ^d
	IAA	BA		
	0.1	0.5	1.3 $\pm$ 0.48 ^a	1.80 $\pm$ 0.13 ^b
	0.1	1.0	1.9 $\pm$ 0.56 ^{bc}	1.59 $\pm$ 0.12 ^b
	0.1	1.5	2.6 $\pm$ 0.67 ^{cde}	1.04 $\pm$ 0.19 ^{cd}
	0.1	2.0	2.5 $\pm$ 0.53 ^{de}	0.88 $\pm$ 0.13 ^b
	0.1	2.5	3.1 $\pm$ 0.74 ^f	0.61 $\pm$ 0.18 ^a
	NAA			
	0.1	0.5	1.3 $\pm$ 0.48 ^a	1.59 $\pm$ 0.51 ^f
	0.1	1.0	1.5 $\pm$ 0.52 ^{ab}	1.21 $\pm$ 0.18 ^c
	0.1	1.5	2.0 $\pm$ 0.60 ^{bcd}	0.91 $\pm$ 0.15 ^{bc}
	0.1	2.0	2.4 $\pm$ 0.69 ^{cde}	0.83 $\pm$ 0.12 ^b
	0.1	2.5	2.7 $\pm$ 0.82 ^e	0.59 $\pm$ 0.11 ^a
		TDZ		
		0.05	2.2 $\pm$ 0.69 ^a	1.1 $\pm$ 0.22 ^c
		0.10	2.8 $\pm$ 0.80 ^{ab}	1.2 $\pm$ 0.14 ^d
		0.15	3.6 $\pm$ 0.70 ^{ab}	1.1 $\pm$ 0.14 ^c
		0.20	3.8 $\pm$ 0.40 ^b	1.0 $\pm$ 0.11 ^b
		0.25	4.1 $\pm$ 0.60 ^b	0.6 $\pm$ 0.21 ^b

Any having the same letter is not significant at the 5% level

for TDZ are reported in the case of *Malus pumila* (Huetteman and Preece, 1993). White's medium along with the auxins and cytokinins, did not induce shoots from any of the explants used. Cotyledon and hypocotyl induced white callus initially, from the whole surface of the explant which eventually turned brown in all the media concentrations tried. From the root segments, white globular bodies were produced, which were attached to the explant and later turned brown and did not show any regeneration potential in any of the media used.

Three to four shoots were induced from single nodes of the isolated shoots on MS medium containing IAA 0.1 mg l⁻¹, BA 1.0 mg l⁻¹ and additives within a period of 16-20 days (Fig. 2).



Fig. 2. Multiple shoot induction from the isolated shoots of *C. wightii* on IAA 0.1 mg l⁻¹, BA 1.0 mg l⁻¹ and additives.

At higher concentration of BA, the shoots induced were small and during subculture to fresh media dried off (Table 2). Increasing the level of auxins resulted in the formation of white friable callus from the entire surface of the explant.

2. Rooting and acclimatization of plantlets

Half strength MS medium containing 0.25 mg l⁻¹ IBA was found to be the best for strong and viable root induction from the isolated shoots within 10-12 days. Two or three roots (ca. 3-4 cm in length) induced from the shoots during the culture period (Fig. 3). The root inducing capacity of IBA along with half strength MS

Table 2. Effect of different concentrations of IAA and BA on shoot multiplication of *C. wightii* in MS medium containing additives. (Data collected after 21 days)

IAA + BA (mg l ⁻¹)	No. of shoots ± SE	No. of shoots ± SE	Callus intensity
0.05 + 0.5	1.2 ± 0.8 ^a	1.1 ± 0.2 ^d	-
0.05 + 1.0	1.4 ± 0.6 ^b	1.0 ± 0.2 ^c	-
0.05 + 2.5	2.1 ± 0.4 ^{bcd}	1.0 ± 0.1 ^c	+
0.05 + 5.0	2.8 ± 0.6 ^{ab}	1.0 ± 0.1 ^c	+
0.10 + 0.5	1.8 ± 0.5 ^{bc}	2.5 ± 0.7 ^d	-
0.10 + 1.0	3.3 ± 0.6 ^{cde}	3.1 ± 0.5 ^e	-
0.10 + 2.5	3.5 ± 0.4 ^f	1.8 ± 0.6 ^a	+
0.10 + 5.0	3.8 ± 0.6 ^{cde}	1.5 ± 0.2 ^b	+
0.25 + 0.5	1.6 ± 0.4 ^{ab}	1.2 ± 0.6 ^c	-
0.25 + 1.0	1.8 ± 0.2 ^{bcd}	1.1 ± 0.4 ^{bc}	-
0.25 + 2.5	2.2 ± 0.1 ^{cd}	1.0 ± 0.2 ^{ab}	+
0.25 + 5.0	2.6 ± 0.2 ^{ef}	1.0 ± 0.4 ^{bc}	+
0.50 + 0.5	1.2 ± 0.2 ^{ab}	1.0 ± 0.2 ^d	-
0.50 + 1.0	1.4 ± 0.4 ^a	1.1 ± 0.4 ^d	-
0.50 + 2.5	2.1 ± 0.2 ^b	1.0 ± 0.6 ^b	+
0.50 + 5.0		2.8 ± 0.4 ^b	+

- no callus, + moderate callus

Any having the same letter is not significant at the 5% level

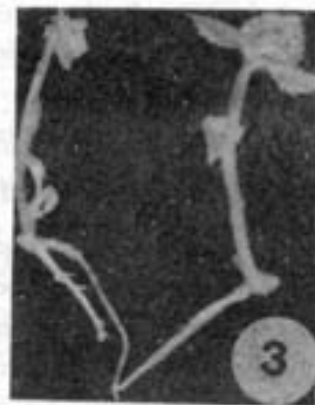


Fig. 3. Root induction from the isolated shoots of *C. wightii* on half strength MS medium containing 0.25 mg l⁻¹ IBA.

medium is reported to be better than IBA along with full strength MS medium (Rout *et al.*, 1999). Higher concentrations of IBA induced white friable callus from the basal portion of the shoots and tip burning of shoots. All the media along with IAA and NOA were less effective for root induction as they induced small fibrous roots along with watery callus from the basal portion of the shoots. Concentrations of NOA used, produced weak roots with brownish callus (Table 3). Full strength

Table 3. Effect of different auxins on root induction from the isolated shoots of *C. wightii* on half strength MS medium. (Data collected after 21 days)

Auxins used (mg l ⁻¹)	No. of roots/shoot ± SE	Length of roots ± SE	Callus intensity
Control	1.4 ± 0.5 ^a	0.5 ± 0.1 ^a	-
IAA			
0.05	1.0 ± 0.2 ^a	0.8 ± 0.1 ^a	-
0.10	1.2 ± 0.8 ^{ab}	0.9 ± 0.2 ^{ab}	+
0.25	1.0 ± 0.6 ^a	0.6 ± 0.3 ^a	+
0.50	-	-	+
IBA			
0.05	1.0 ± 0.1 ^{ab}	0.5 ± 0.06 ^a	-
0.10	2.0 ± 0.6 ^{cd}	0.8 ± 0.08 ^{ab}	+
0.25	3.3 ± 0.5 ^{cde}	1.7 ± 0.30 ^{bcd}	-
0.50	2.0 ± 0.6 ^{de}	1.4 ± 0.4 ^{cde}	+
NOA			
0.05	1.0 ± 0.1 ^{ab}	0.3 ± 0.1 ^a	-
0.10	1.4 ± 0.1 ^{abc}	0.5 ± 0.1 ^a	+
0.25	1.6 ± 0.2 ^{bcd}	0.4 ± 0.1 ^a	+
0.50	1.8 ± 0.2 ^{cde}	0.2 ± 0.1 ^{ab}	+

- no callus, + moderate callus, ++ high callus

Any having the same letter is not significant at the 5% level

MS, 3/4 MS and 1/4 MS nutrient media were found to be inefficient and induced only small fibrous roots with good amount of callus from the basal portion of the shoots.

Actively growing plantlets were transferred to autoclaved soilrite in glass bottles (Fig. 4)



Fig. 4. Hardening of rooted plantlets of *C. wightii* in glass bottles containing autoclaved soilrite enriched with one fourth MS nutrient salts.

moistened with 1/4 liquid MS nutrient salts and were transferred to pots containing sandy soil (Fig. 5). All the plantlets transferred to the soil survived.



Fig. 5. Forty five days old pot transferred hardened plantlets of *C. wightii*.

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INDIAN MATCANE *Schumannianthus dichotomus* (ROXB.) GAGNEP : AN UNDERUTILIZED FIBER PLANT OF INDIA

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Schumannianthus dichotomus, the matcane of tropical Asia is underexploited. The plant is cultivated for the preparation of mats in the North-eastern parts of India. This fiber plant could prove to be a great asset for the rural economy. The present investigation provides information on the cultivation and economics of this neglected species.

Key words : *Schumannianthus dichotomus*, Indian matcane, systematics, cultivation, processing, uses

Schumannianthus dichotomus (Roxb.) Gagnep., a monocotyledonous plant, belonging to the family Marantaceae, grows sporadically in the north-eastern states of India. The species occurs in the wild form but its economic importance is largely unknown. Very less attention has been given to this plant species for its improvement and development. The species has enormous potential and is commercially viable if cultivated on large scale. This may help to uplift the rural economy and render the waterlogged and semi-aquatic wasteland areas of tropical environment for cultivation.

1. Distribution and Botany

The genus *Schumannianthus* Gagnep has 2 species i.e., *S. dichotomus* (Roxb.) Gagnep. and *S. virgatus* (Roxb.) Rolfe. The genus is distributed in Sylhet (Bangladesh), Assam, Tripura, Cooch-Bihar and Coromandel coast (South India), Tenasserim (Myanmar), Thailand, Cambodia, Cochinchina and Philippines. The species of *S. virgatus* (syn. *Clinogyne virgata* (Roxb.) Benth.) is confined to Southern India and Andaman-Nicobar

island. It occurs in both wild and cultivated forms. Wild varieties are normally small and less robust than the cultivated variety. The species is found in low-lying areas of Assam, Tripura and some pockets of North Bengal, in north-eastern parts of the country. Existing herbarium (ASSAM) collections reveal that it occurs in Kamrup, Sibsagar, Jorhat, North Lakhimpur, Cachar, Karimgunj, Nagaon and Goalpara districts of Assam whereas in North Bengal, it is confined to some areas of Cooch-Bihar district. In Tripura it grows in low-lying areas of West Tripura district. In southern parts of India, it grows in Coromandel Coast. The major cultivation of the species is being done in Cachar and Goalpara districts of Assam by about 200 farmers and in Cooch-Bihar district of North Bengal, by about 60 farmers.

This little known species normally grows in low-lying areas where water remains stagnant, over a long period. The species grows well in riverine alluvium, yellow loams and raw humus type (grey to black in colour) of soil. The species

Schumannianthus dichotomus (Roxb.) Gagnep., earlier known as *Clinogyne dichotoma* Salisb., is a member of the family Marantaceae. The *Schumannianthus dichotomus* is basically spread over in India, Sri Lanka, Myanmar and Indo-Malayan region. In India, the species locally known as 'Muktapata', 'Madurpata' in Bengali language, while in Assamese it is known as 'Patidoi', 'Mutra' (Wlth India, 1950). The plant is an erect shrub of ca. 5 m tall, 2 cm in diameter without any nodes except the apical portion which is dichotomously branched. The leaves are ovate-oblong in shape with variable size of 8-15 × 3.8-5 cm. The inflorescence is panicle with 7.5 to 10 cm. in length and it bears small, white flowers which are ca. 2.5 cm. in length. The fruits are 1.5 cm in diameter, indehiscent with 2-3 lobed and each lobe contains single seed.

The plant starts flowering from April onwards and fruit sets within 3-4 months which lasts up to August.

2. Cultivation

The plant propagates vegetatively either through transplanted rootstock or cuttings. Rootstocks form twice in a year, in April-May and October-November, when there is no stagnation of water. Propagation can also be done through the seeds. Seeds are normally collected in June-August, dehusked and dried in sunlight. The nursery is laid in February-March and the sapling grows in April-May. When the saplings turn 18-20 cm. long or attain two to four leaf stage, they can be transplanted. Four to five seedlings per hill are planted at 20-25 cm distance

apart in muddy soil. Fertilizers are not needed initially. However, farmyard manure can be used after first weeding and it is to be done at the tillering initiation stage. The process is repeated for the second year from the previous year's plant at maturity. Thus it takes at least two years to produce the raw material (Fig. 1).



Fig. 1. Cultivated field of *Schumannianthus dichotomus*

Multiplication and raising of seedlings is done either through direct sowing of seeds or cutting of one year old rootstock. In direct seed sowing, it requires two years time while in later case only one year for establishment of plants. However, rootstock saplings take a little more time than direct seeded plant for their establishment in soil because roots get damaged during the cutting and thus saplings become weak. Later on, when new sprouts are grown from these established saplings, they grow very rapidly and become thick and strong. On the other hand, direct sown seed turns into plants faster but become comparatively thin and slender due to their dense population. These plants are of superior quality since they yield superior and thin splits for weaving of valuable mats. Harvesting of cane

yield starts from third year onward after sowing or transplanting (Fig. 2). Once the plants got



Fig. 2. Harvested species of *S. dichotomus*

established and started to yield from 3rd year onward, they continue to grow and yield continues for decades unless plants are abandoned. Therefore, regular weeding and tillage in between the hills are necessary every year during the month of March-April. In order to avoid deterioration of the yield in natural condition or to rotate the crop, harvesting may be done during the 6th year, otherwise the plant can be harvested for its selected canes every fifth year which may be continued till it is abandoned.

3. Diseases and pests

This semi-hydrophytic species is attacked by a few diseases and pests. However, little recorded

information is available on its susceptibility to diseases. Rats create menace to this plant when water is dried up in the field. They make holes in root zone and gnaw at the tender roots. Grazing is not a major problem because the leaves are not favoured by cattle. The tender plants got damaged when they splash through the unfenced fields. Birds use these plants for their nests and deteriorate the quality of reed then their faeces stain and contaminate the reed.

4. Processing

The nodeless reeds are harvested from the base and split lengthwise into thin slats. The slats are classified according to their degree of processing which determines the quality of mats. Slats are broadly classified into five types but their anatomical distinctions cannot be done in a strict manner.

i) *Stem splits* - The rounded stem split into four major longitudinal sections, wherein the pith portion.

ii) *Cortical splits* - Longitudinal sections of stem splits are further split, leaving aside the endodermal portion is not included.

iii) *Primary cane splits* - Splits are obtained from cortical split after soaking in water for an hour. These splits consist of smooth, green epidermal portion (outer layer) of the stem.

iv) *Secondary cane splits* - After removing the primary layer of cane splits, the second coarse layer reveals a matrix of xylem and bast fibre groups which form the secondary cane splits.

v) *Tertiary cane splits* - The remaining portion of cortical splits are called tertiary cane. These are rough and coarse and may be utilised for thatching or tying purpose. Ash from the pith portion of the splitted stem are also utilised as alkali for washing clothes.

Cool mat is prepared from primary cane split, the epidermal portion, which remains smooth

and glossy. It does not absorb the temperature easily. For processing such split in order to make cool mats, a large earthen pot is filled up with rice starch or with water with rice soaked in it for at least a week. Acidic leaves of *Tamarindus indicus*, *Phyllanthus niruri*, *Oxalis corniculata* and *Averrhoa carambola* may be threshed into a paste and added to this water. This mixture is then filtered and kept safely in a cool place. The freshly harvested and prepared primary cane splits (without pre-soaking in water) are then immersed in a soil form in processed water (starch + acidic leaves) as indicated above. Sunlight and wind should be avoided during this process. After 3-4 days, the cane splits are boiled with water in an aluminium pot. After boiling for thirty minutes, the splits are allowed to cool down, cleaned in

water and dried in sunlight. These cane splits are then used for knitting (Fig. 3).

If coloured fibres are required, the splitted coils are soaked in warm coloured water with colour or choice and then boiled for at least five minutes. A little common salt may be added and the mixture boiled again for another 2-3 minutes. Later on, the splits can be cleaned in water and dried in a shady place to get the proper tinge of colour.

5. Uses

Split, polished and glossy stems of the mature plant are used for knitting mats, hats, curios, bags, cushions etc. The strips are separated from the stem and are sorted under different grades. Quality and gradation determine the nature of the split and degree of processing. The rhizomatous portion of the plant yields a commercial starch (Winton and Winton, 1935).

6. Cost and benefits of the cultivation

The cultivation of the matcane is a lengthy process. However, weeding and tillage between the hills are necessary during the months of March and April every year. The plant starts yielding in the 3rd year onwards of each new plantation. Dey (1987) calculated the total economics of the cultivation and production based on one location while the present author had surveyed two different locations and interacted with the farmers. According to the market price of 1990-91, the approximate cost expenditure for cultivation has been shown in Table 1. This is based on the survey of rural market where it is sold.

The annual return from the crop starts from the 3rd year onwards. As the 'hills' become gradually mature the number of reeds also increase in each subsequent year and the peak yield is attained in the 6th year, when the reeds can also be harvested completely. The quantity of production per hectare of raw material and their

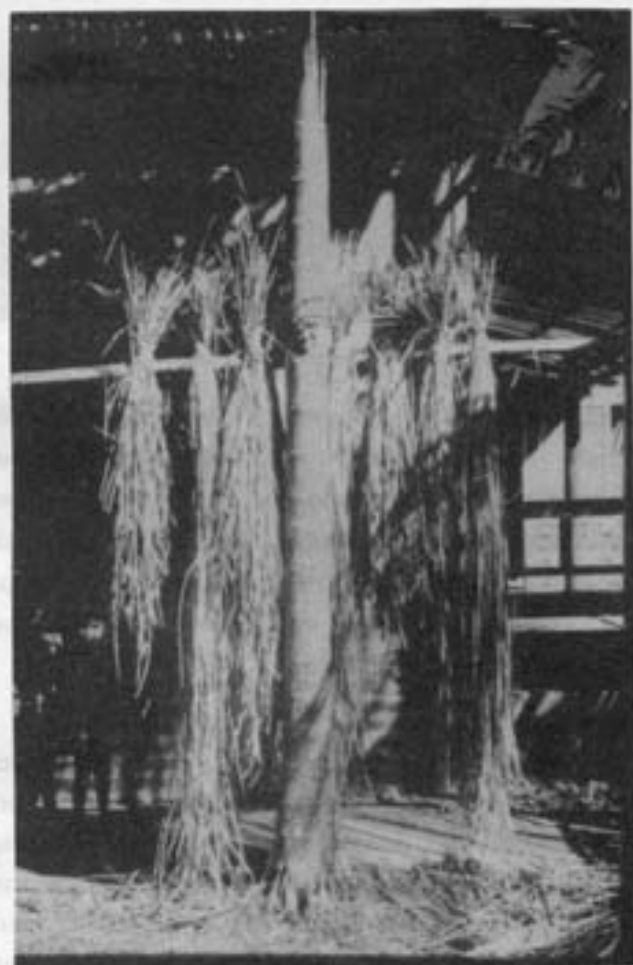


Fig. 3. Fibre strips of *S. dichotomus* being dried in sun

Table 1. Cost of cultivation per hectare since beginning of harvest

Year	Cultural operations	Amount (Rs.)	Total (Rs.)
1. First Year	i) Seedling	19000.00	22750.00
	ii) Cultivation, planting and fertilizer	3750.00	
2. Second Year	Fencing, weeding, fertilizer application and other nursing	3750.00	3750.00
3. Third Year	-Do-	3750.00	3750.00
			Rs 30220.00

corresponding rate in terms of per mat including the manufacturing cost have been shown in the Table 2. Qualitywise harvest from third year's plant is a bit inferior due to non-glazed and stained surface of the reed (fetching a low rate). During the harvest of the fourth year's plant, the mature plants are extracted only after they are selected. The rate of these culms is a little more than the third year's harvest due to the



Fig. 4. Prepared conemat being dried before marketing

Table 2. Production per hectare of mats and returns over different years of crop growth

Year	Production - in terms of material for number of mats $\times$ rate (Rs.)	Amount (Rs.)
i) Third Year	375×10.00	3750.00
ii) Fourth Year	750×15.00	11250.00
iii) Fifth Year	1250×20.00	22410.00
iv) Sixth Year	300×20.00	60000.00
		Rs 97410.00

degree of maturity. However, the fifth and sixth year's harvested reeds yield best quality, thus fetching superior price in the market. Now plantations can be done in the same field next year after completely harvesting the previous crop. In this process, the cultivation prevents the deterioration of the field.

When the mats are knit, each mat costs roughly from Rs. 15/- to 300/- depending on the quality and design. It was observed that the profit is approximately five to six times over the investment, which includes the processing and knitting cost. The demand is limited locally due to poor purchasing capacity of the rural people,

whereas in large towns and cities, the mats fetch a lucrative price (Fig. 4).

7. Future prospects

The cultivation of crop needs to be boosted up on a large scale which can promote the cottage industry in the North-eastern region of India and its neighbouring tropical countries. Marshy, waterlogged wastelands can be utilised for the cultivation of such crops that require minimum care and attention. Farmers may be encouraged to cultivate such crop by allotting Panchayat wastelands by the Government/authorities alongwith subsidised loan for cultivation. Cooperative marketing system will be ideal and may be introduced so that the farmers may get proper market price for their raw as well as manufactured products. The plant yields sufficient quantity of fibre and can be utilized for the manufacturing of paper. If the cultivation extended to large scale and the production enhanced, this can be a good substitute of mats prepared from the strips of *Calamus* spp. which is now over exploited. Besides, the preparation of mats, the fibres may be used for making various artifacts,

curios, hats, baskets etc. which can earn some foreign exchange too. At present, the marketing scope is confined to the region but it can be extended to other parts of the country and may even be exported outside the country. Marketing scope will then be widened when more people will come to know about its importance and variety of uses.

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EXPLORATION OF URIDBEAN FROM DIVERSITY ZONES IN UTTAR PRADESH

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The variability in uridbean was collected from diversity pockets of Uttar Pradesh, India in districts Sitapur, Hardoi, Barabanki, Bareilly and Kumaon Garhwal Divisions. The presence of diverse types was found in more abundance in Kumaon Garhwal Division and Hardoi districts of Uttar Pradesh.

Key words : Exploration, landraces, uridbean

Black gram or urid bean (*Vigna mungo* (L.) Hepper is one of the Asiatic *Vigna* species, which has herbaceous annual habit and belongs to the family leguminaceae sub family Papilionaceae. The crop is grown in India, Bangladesh, Pakistan, Srilanka and Myanmar. India, being a centre of origin and diversity for urid bean, exhibits a rich variability for various agromorphological traits. The largest collections of 1414 exists in India. Betton Court *et al.* (1989) has reported collections in other countries like Pakistan (479), Bangladesh (339), USA (227), China (169), Japan (34), Senegal (10) and Togo (6) also.

In Uttar Pradesh, Hardoi, Barabanki, Bareilly, Sitapur and eight hill districts in Kumaon and Garhwal divisions have been identified to be still rich in diversity for local types in this crop (Paroda and Arora, 1991). This diversity is basically conserved by local farmers and people in the form of remanent seed. These centers of diversity are in constant process of genetic erosion as the areas are under rapid urbanization and intensive cultivation. The high yielding varieties are rapidly replacing the local landraces. Unfortunately, progress in breeding after selection and purification

of genetically mixed landraces inevitably led to more uniformity and less genetic variability within the variety that was presented in the original land race. The variability in existing collections of Urid bean is limited and potential donors are yet to be identified (NBPGR, 1990). Keeping this in view, explorations were undertaken in the diversity rich districts of Uttar Pradesh in the year 1996 to 1998.

The experimental area of exploration and collection included plains and irrigated zones with characteristic sandy loam to loam soils while hill districts of Kumaon and Garhwal, the mid hill elevations areas were basically rainfed. The samples were collected from farmer's field, village and backyards in village home.

During the discussion with farmers, it was noted that diverse pattern does exists in the cultivation practices, seed characters, and consumer preferences. In the plains of Hardoi, Sitapur and Barabanki, the cultivation of Urid bean is basically is intercrop or in the marginal lands. The intensive cultivation of this crop was less. The plant type preferred were trailing types with high amount of green foliage. The seed colour preferred was

also green type due to its basic use in culinary preparations other than "dhal". The flowering period and maturity patterns were reported to be asynchronous which is an undesirable trait. There is an need to develop genotypes with green seed and erect plant habit for these areas. In Bareilly, the consumer preference is for bold, black seeded and erect types as the intensive cultivation is also practiced. The variability for local land races was found limited as compared to material from other hill and plain zones.

In the hill districts of U.P. the variability for plant types was considerable in the valleys. The sowing season also extends from March to June which is basically dependent on availability of water. The diversity for seed characteristics is

quite high viz., seed colour (light green, green brown, chocolate, black, mottled) seed size and (bold to small grains). It was noteworthy that hill districts of Uttar Pradesh have substantial variability in Urid bean germplasm and possibility of unique types also exists. The areas require an intensive exploration not only for Urid bean but for all other type of beans also.

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COLLECTION, EVALUATION AND CONSERVATION OF HORTICULTURAL CROPS IN UTTAR PRADESH HILLS

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The Himalayas represents a rich repository of diverse flora with different ecosystem. Central Himalayas of Uttar Pradesh hills is the seat of a large number of minor fruit crops both tropical and temperate species. Since inception of NBPGR Regional Station in 1986, systematic approach was made to collect germplasm of different agri-horticultural crops from UP hills. A total number of 1018 accessions of horticultural germplasm viz., strawberry (81), *Citrus* (50), *Malus* (26), other fruits (81), vegetables (623) and ornamentals (157), were collected/assembled and evaluated for various qualitative and quantitative characters. The fruit germplasm has been conserved in field gene bank and vegetables and annual ornamentals under medium term at this Station and promising accessions identified. IC 219062 (*Diospyros kaki*), IC - 219058 in Jogiya Hisalu (*Rubus* sp.), EC - 362602 in strawberry, Haward and Allison in kiwi fruit were found to be quite promising, details of which are highlighted in this paper.

Key words : PGR, collection, evaluation, conservation, fruits, ornamentals

In India, the endemic species are generally distributed in two distinct areas, approximately 4200 species in Himalayas and 2600 species in peninsular region. Although indigenous fruit plant species occurring in India is meagre, several wild relatives are said to be originated in this region (Zevan and Zhukovsky 1975; Arora and Nayar 1984). Some of the fruit species, where rich diversity occurs in India, included banana and plantain (*Musa* sp.), jackfruit (*Artocarpus* sp.), mango (*Mangifera* sp.), anola (*Emblica officinalis*), Karonda (*Carissa* sp.) etc. A number of wild species of some of the important and commercial fruits are said to be originated in this region viz. grapes (*Vitis lanata* Roxb., *V. oblecta* Wall., *V. polystachya* Wall. and *V. pyrenantha* Coll. & Hems; *Citrus* (*Citrus ichangensis* Swingle, *C. letipes* Tanaka, *C. macroptera* Mont., *C. assamensis*, *C. aurantium*

L., *C. jambhiri* Lush, *C. limonia* Osbeck and *C. karna* Kaf.). date palm (*Phoenix* spp.), apple (*Malus sikkimensis*), cherry (*Prunus nepaulensis*), pear (*Pyrus khasiana*) etc. (Arora, 1985; Bhattacharya and Dutta, 1951, 1956; Dutta, 1958; Krishnamurthy and Seshadri, 1958; Mukherjee, 1949; Patil, 1993 and Singh, 1967).

The Himalaya represents a rich repository of diverse flora with different ecosystem. UP hills play host to a large number of minor fruits crops from tropical to temperate species because of great altitudinal differences in the region coupled with varied physiography which contributes to great climatic variations viz. from tropical forest to sub tropical, temperate, sub alpine, alpine and cold arid zone vegetation. Most of the fruits grow wild. Endowed with medicinal, therapeutic or commercial value, the fruits are also attractive,

congenial in taste and quality. Even then the fruit wealth of these areas is gradually becoming extinct and this is the time to collect the traditional and wild fruit plant (Paroda *et al.* 1988).

Horticultural crops in UP hills

The hilly region of Uttar Pradesh constitutes mainly Garhwal and Kumaon hill region of North-western and Central Himalayas and spread over an area of 51125 sq. km. with total population of 58.74 lakhs, as per 1991 census. Agriculture is one of the major occupation of the natives residing in the region. Two types of agricultural systems are followed by local people and tribals; mixed cropping in mountainous region and intensive cropping pattern in valley areas. Due to inadequate irrigation facilities, most of the areas are totally dependent on the seasonal rains/monsoon. Rich variability in fruits were reported in *Pyrus*, *Prunus*, *Sorbus*, *Malus*, *Rubus*, *Ribes*, *Hippophae*, *Juglans*, *Colrylus* and *Myrica* (Joshi and Rana, 1994). The other wild and semi domesticated fruits *Ziziphus*, *Citrus*, *Ficus*, *Morus*, *Aesendra* and *Embllica* are well distributed. In vegetables and tuber crops, good variability occurs in pumpkin, bottle gourd, snake gourd, ridge gourd, bitter gourd, peas, tomato, in leafy vegetables viz., spinach, fenugreek, amarnath and chnopods. Among tuber crops, variability was observed in potato, *Colocasia*, ginger, *Dioscorea* and turmeric. In medicinal plants, diversity is represented by *Aconitum*, *Taxus*, *Swertia*, *Rheum*, *Potentilla*, *Carum* and *Berberis* and in ornamentals, tremendous variability has been observed in *Gladiolus*, *Rosa*, *Gerbera*, *Rhododendron* and *Gloriosa*.

1. Explorations and collections

Numerous plant explorers surveyed this part of UP Hills since 1796. Some of them were Thomas Hardwickee, Strachey and Winter Bottom (1846-49), Osmaston (1927), Sonythe (1932), and M.B. Raizada (1938). Several fruit crops were

brought to India from other regions by travellers, invaders like Parsians, Turks, Moghals, Portuguese, Dutch, French and British. The introductions made in the past were maintained in various institutes throughout the country and also at Chaubattia in UP Hills (Chadha and Pareek, 1993; Paroda *et al.*, 1986). Since its inception, National Bureau of Plant Genetic Resources, Regional Station, Bhowali, Nainital, (Uttar Pradesh) in 1986 which is actively engaged in collection of agrihorticultural crops from UP hills and also in evaluation, characterisation, multiplication, maintenance, diseases screening, cataloguing and enrichment of germplasm by introducing exotic plant material. Out of crop specific explorations specially for *Citrus*, *Fragaria* and other minor fruits were also collected. Consequently 1018 collections of horticultural germplasm have been made (Table 1).

2. Horticultural germplasm and their evaluation

(i) Fruit crops

A total of 238 accessions of fruits were collected/acquired from exotic resources (Table 1). They include *Fragaria* sp. (81), *Actinidia* sp. (7), *Citrus* sp. (50), *Malus* sp. (26), *Sorbus* sp. (1), *Prunus* sp. (6), *Pyrus* sp. (9), *Castanea* sp. (1), *Physalis* sp. (1), *Ziziphus* sp. (3), *Morus* sp. (2), *Rubus* sp. (15), *Vitis* sp. (4), *Juglans* sp. (1), *Ficus* sp. (7), *Myrica* sp. (1) *Diospyros* sp. (1), and *Carissa* sp. (1), *Elaeagnus* sp. (1), *Syzygium* sp. (1), *Cordia* sp. (1) and other minor fruits (18). Elite material in Kaku (*Diospyros kaki*) was collected from Kashyalekh area of Nainital district having very good aroma and taste with attractive eye appealing colour. A few collections like *Hippophae* sp. need specific ecological requirements for conservation. *Rubus* spp. exhibited special distribution pattern. *Rubus ellipticus* and *R. nivens* showed widespread distribution in Kumaon hills whereas *Jogiya hisalu* (*Rubus* sp.) is confined to some pocket like Mukteshwar and China peak of Nainital.

Table 1. Horticultural germplasm collected/maintained at NBPGR Regional Station, Bhowali, Nainital, UP

S. No.	Crop group/crops germplasm	Total	Promising accessions
Fruit crops			
1.	Strawberry	81	NIC-14837, NIC-18074, NIC-18075, NIC-18080, NIC-18123, NIC-20966 & EC-362602
2.	Kiwi	07	Hayward and Allison
3.	Citrus	50	-do-
4.	Apple	26	-do-
5.	Other fruits	74	-do-
		238	
Vegetable crops			
6.	Chillies	600	EC-362899-C, EC-362901, EC-362903, EC-362918, IC-119699, IC-119703, P-2072
7.	CHow-chow	10	-
8.	Others	13	-
		623	
Ornamental crops			
9.	<i>Gladiolus</i>	31	NIC-14888, NIC-14893, NIC-14895, NIC-14899, NIC-14901, NIC-14903, NIC-14909
10.	<i>Tagetes</i>	32	-
11.	<i>Dahlia</i>	18	-
12.	Others	76	-
		157	

(a) *Fragaria* sp. : A total 81 accessions were evaluated for 32 descriptors. NIC-14837, 18074, 18075, 18080, 18083, 18089, 18123, 20966 were found promising and EC-362602 showed large fruit size with improved keeping quality. Other top ranking accessions with their respective characters have shown in Table 2.

(b) *Actinidia chinensis* : EC-367653 was established and multiplied for onward supply on Hayward root stock. Other varieties Hayward,

Table 2. Strawberry evaluation in UP Hills

Variable	Min.	Max.	S.D	To ranking accessions
Plant height (cm)	7.10	34.00	5.91	NIC-18134, NIC-18110, NIC-18113, NIC-18114, NIC-18112
Number of runners/plant	0.00	5.00	0.95	NIC-18119, NIC-18090, NIC-18119, NIC-18108
Length of runner (from main plant to node) (cm)	0.00	25.30	4.36	NIC-18126, NIC-18112
Days to 50% flowering	41.00	124.00	17.26	NIC-18076, NIC-14837
Fruit length (cm)	1.00	5.60	0.63	NIC-18074, NIC-18090
Fruit width (cm)	1.21	2.47	0.24	NIC-18074, NIC-18075, NIC-18123.
	2.10	12.30	1.79	NIC-18074, NIC-18075, NIC-18076.
	2.00	37.50	5.05	NIC-18074, NIC-18075, NIC-18076, NIC-18081
	2.00	30.40	4.43	NIC-18123, NIC-14837.

Bruno, Allison, Monty and Abbot fruited well. Acidity, TSS and other physico-chemical traits were analysed (Table 3) in all accessions at Department of Horticulture, G.B. Pant University of Agriculture and Technology, Pantnagar, Udham Singh Nagar, UP.

(c) *Citrus* sp. : Forty five collections *Citrus* sp. from Kumaon region with its related genera, *Poncirus trifoliata* were maintained which includes *Citrus sinensis*, *C. medica*, *C. jambhiri*, *C. aurantifolia*, *C. reticulata*, *C. decumana* and *Citrus mitis*.

Table 3. 3 Kiwi Evaluation for fruit characteristics

Variable	ABBOT	ALLISON	BRUNO	HAYWARD	MONTY	S.E.
Fruit length (cm)	5.39	5.77	5.44	5.47	5.21	0.08
Fruit width (cm)	3.71	3.27	3.63	3.42	3.56	0.05
FSI.	1.45	1.76	1.50	1.59	1.46	0.03
Fruit weight (g)	45.23	34.18	45.20	38.70	40.50	1.93
Fruit volume (ml)	45.06	33.97	43.70	39.70	39.25	2.04
SPG.	1.01	1.00	1.03	0.98	1.03	0.01
Peel weight (g)	7.20	5.53	6.80	6.81	6.02	0.31
TSS (%)	11.86	12.95	13.56	14.98	12.51	0.30
Acidity (%)	1.90	2.23	1.76	1.66	2.22	0.09
TAR.	6.27	5.84	7.95	9.06	6.55	0.33
ASA. (mg/100g)	10.34	10.34	6.89	5.17	9.21	1.33
Flesh(%)	83.77	67.37	86.85	82.43	84.89	2.94
Peel (%)	16.22	17.62	15.79	17.57	14.61	1.07
PPR.	5.60	5.56	5.62	5.05	6.36	0.39

FSI. - Fruit shape index., SPG. - Specific gravity., TAR. - Tss acid ratio. ASA. -Ascorbic acid., PPR. - Pulp peel ratio

(ii) Vegetable crops

(a) *Capsicum* sp.: A total of 289 accessions were evaluated for 30 descriptors. Variability was recorded for fruit colour (green, purple, black, yellow, orange and red) and fruit shape (elongate, oblate, round, conical and bell or blocky type). EC-362899-C, EC-362901, EC-362903, EC-362918, EC-362922, EC-362925, EC-362930, EC-362938, EC-339047, IC-092123, IC-119200, IC-119203, IC-119216, IC-119235, IC-119241, IC-119280, IC-119305, IC-119381, IC-119203, IC-119216, IC-119235, IC-119241, IC-119280, IC-119305, IC-119381, IC-119387, IC-119408, IC-119557, IC-119629, IC-119669, IC-119699, IC-119703, IC-119703, IC-119706, IC-1199709, IC-119718, IC-119743, IC-119746, IC-119747, IC-119773, IC-119787, NIC-19943, NIC-19944, NIC-19949, NIC-19988, NIC-23393, NIC-23394, NIC-23396, NIC-23398, NIC-23399, P-1893, P-2072, SKV-433 and SKV-434 were found promising. Exotic accessions mainly *Capsicum annum*, *C. baccatum* and *C. chinense* were attractive and ornamental plants. (Table 4).

Table 4. Chillies evaluation in UP hills

Variable	Minimum	Maximum	Mean	Sum	S.Error
G	82.00	117.00	95.37	27562.00	0.47
PH	7.50	96.50	45.30	13092.45	0.73
PC	10.60	2610.50	938.23	271149.79	26.79
LL	4.40	17.30	9.36	2706.50	0.11
LW	1.60	6.00	2.78	806.10	0.03
DFL	160.00	220.00	168.09	48580.00	0.37
DFR	178.00	250.00	195.26	56432.00	0.41
FRNO	1.00	95.00	16.29	4710.30	0.67
FL	1.50	11.80	5.24	1515.45	0.08
FW	0.12	3.25	0.95	275.90	0.02
FG	1.50	65.50	21.70	2673.30	0.64
FDG	0.20	12.50	5.43	1569.50	0.15

G - Days to 50% germination; LL = Leaf length (cm); LW - Leaf width (cm); PH - Plant height (cm); PC - Plant canopy (sq. cm); DFL - Days to 50% flowering; DFR - Days to 50% fruiting; FRNO - Fruit number/plant; FL - Fruit length (cm); FW - Fruit width (cm); FG - Fruit green weight (g); FDG - Fruit dry weight (g);

(b) *Sechium edule* : A total 10 accessions were maintained in the field gene bank. Yield and fruit weight per plant varied from 3-51 fruits per plant 180-556g per fruit.

3. Horticultural germplasm conservation

There is an assortment of legislation in UP hills relating to the indigeneous/endemic flora and fauna. Wild life sanctuaries e.g. Corbett National Park (52082 ha. in Pauri), Govind Wild Life Sancturries (95312 ha. in Uttarkashi), Kedarnath Wild Life Sancturries (96.726 ha. in Chamoli), Motichur Wild Life Sancturries (in Dehradun), Nanda Devi National Park (63033 ha. in Chamoli), Rajaji National Park (in Dehradun), Valley of flowers (8750 ha. in Chamoli), have been established to oversee conservation and preservation of Himalayan heritage.

Ex-situ conservation, either in field gene bank (*in vivo*) or *in vitro* conditions also serves as base collection is maintained in case of fruit crops like *Citrus*, strawberry and rosaceous fruits and also in case of bulbous ornamentals. This station has also given responsibility of secondary centre of chillies evaluation. Presently 289 accessions were evaluated for 2 consecutive years and total 600 accessions are under evaluation. Other accessions of Chow chow (10) and 10 *Cucumis* sp. are under evaluation and multiplication for seed increase for long term conservation at NBPGR, Pusa campus, New Delhi. In case of ornamentals tubers/rhizomes of *Iris* sp. (4), *Rosa* sp. (14), *Hydrangea* sp. (1), *Pelargonium crispum* (5), *Buddleia* sp. (1), *Jasminum* sp. (1), *Chrysanthemum* sp. (1), *Juniperus* (1) and *Polianthes tuberosa* (1), were maintained in the fields. 39 accessions of different flowering annuals are maintained. *Gladiolus* (31), *Tagetes* (32), *Dahalia* (18), accessions are under evaluation for different traits.

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PERFORMANCE OF SOME PEAR (*Pyrus communis* L) CULTIVARS UNDER MID HILL CONDITIONS OF HIMACHAL PRADESH

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This communication deals with evaluation of six pear cultivars viz., Bartlett, China, Flemish Beauty, Laxton's superb, Max Red Bartlett and Starking Delicious for quality parameters

Key words : Pear, fruit characteristics

The Pear, the second most important delicious tree fruit after apple, has been known since prehistoric times; dried slices have been unearthed in Swiss cave dwelling of the Ice Age (Janic, 1982). Pear ranks third among fruit crops in world production. The common pear (*P. communis* L.) like apple has been selected, improved and cultured since the prehistoric times. It derives possibly from relatively large fruited wild species, *P. caucasica* Fed and *P. nivalis* Jacq. Being a hardy crop, pear can be grown even on marginal lands where other crops are outright failure. According to Singh (1992), pear is the only temperate fruit grown on the hilly part of South India. In India, the major pear growing areas are found in Jammu and Kashmir, Himachal Pradesh, sub-mountain tracts of Uttar Pradesh and the plains of Punjab. Despite early introduction and general popularity, pear is not as widely grown as the apple. Scant attention of Indian researchers towards soft pears might be a possible reason for its low acceptability by the growers. Therefore, the present study was made to assess the performance of some promising genotypes of soft pear grown under mid hill-zone of Himachal Pradesh.

The present investigation was carried out in the experimental orchard of Department of Fruit Breeding and Genetic Resources, Dr. YSPUH&F, Solan in 1992-93 and 1993-94 on twenty six, 17 year old trees of six pear cvs. *Bartlett*, *China*, *Flemish Beauty*, *Laxton's Superb*, *Max Red Bartlett* and *Starking Delicious*. The experiment was laid out in Randomized Block Design and replicated thrice. The fruits were harvested at commercial maturity and subjected to quality evaluation. Fruit size (in terms of length $\times$ diameter) was recorded individually with Vernier Calipers. Skin colour of fruits was determined by matching it with Horticultural Colour Charts issued by the British Colour Council in collaboration with the Royal Horticultural Society, London. Flesh firmness was measured with an Effegi panetrometer - FT 327 and expressed as Newton (Force in Kg $\times$ 9.807). Titratable acidity (%) and total sugars (%) were determined by standard AOAC method (Horwitz, 1980), while total soluble solids ($^{\circ}$ B) of the expressed juice was determined with an Erma hand refractometer (0 to 32%). Starch (%) was estimated by the Anthrone Reagent method (Clegg, 1956). The bioelectrical conductance was recorded

Table 1. Physico-chemical and physiological fruit characteristics of some pear cultivars (Pooled Mean for 1992-93 & 1993-94)

Cultivar	Date of Commercial Picking	Fruit size (length × diameter) (cm)	Weight (g)	Skin* Colour	Flesh Firmness (N)	Titra-ble acidity (%)	TBS (°B)	Sugars (%)	Bio-electrical conductance (m m hos/cm)	Starch (%)	Respirat-ion (mg CO ₂ /kg/h)	Ethy-lene evolu-tion (µl/kg/h)
<i>Barlett</i>	1st-2nd Aug.	6.69×6.35	136.0	YG150A	85.46	0.43	12.29	8.51	4.70	1.57	4.70	21.48
<i>China</i>	18-19th July	5.91 × 5.82	112.30	YG149C	89.69	0.46	12.12	6.91	5.49	1.42	5.50	23.58
<i>Flemish Beauty</i>	25-26th July	6.21 × 6.19	136.50	YG145A	57.73	0.40	12.21	8.85	4.85	1.64	4.95	22.74
<i>Laxton's Superb</i>	1st-2nd Aug.	7.14 × 7.10	174.00	YG150A	90.09	0.43	12.44	8.88	4.61	1.71	4.61	16.00
<i>Max Red Bartlett</i>	8th-9th Aug.	7.08 × 7.02	173.50	RP59A	75.49	0.40	12.17	8.44	4.42	0.93	4.42	17.76
<i>Starking Delicious</i>	1st-2nd Aug.	6.68 × 6.62	149.15	YG149A	85.05	0.40	13.33	8.73	5.62	0.87	5.62	23.17
CD (0.05)	-	0.25	0.22	5.03	-	3.25	0.02	0.18	0.24	0.09	0.06	0.36

*YF-Yellow Green; RP-Red Purple

in m mhos/cm on a direct reading Systonics 303 conductivity meter. The ethylene evolution rate (µl/kg/h) of pear fruits was estimated with gas liquid chromatography as per the method described by Dilley *et al.* (1978). The gas flow method as described by Mayer *et al.* (1966) was employed for the quantitative measurement of respiration as CO₂ evolved in mg/kg/h by the fruit samples.

Data relating to various fruit characteristics indicated that the significantly highest values for fruit size (length × diameter) were recorded by *Laxton's Superb* (7.14 × 7.10 cm) followed by *Max Red Bartlett* (7.08 × 7.02 cm). While *China* pear produced the smallest fruits (5.91 × 5.82 cm). The same pattern was noticed for fruit weight and the highest (174.0 g) and the lowest (112.30 g) values were registered by *Laxton's Superb* and *China*, respectively. Cultivars did not show much variation for skin colour and ranged between Yellow Green 149C to 150A except in

the red pigmented cultivar *Max Red Bartlett* which was lying in the range of red purple i.e. RP 59A.

At the time of commercial picking, *Flemish Beauty* pear produced the most soft fruit showing lowest flesh firmness (57.73 Newton), while it was the highest in *China* (89.69 Newton). Moreover, cultivar *China* was more acidic (0.46%) than other cultivars. The total soluble solids (TSS) of fruit was significantly high in *Starking Delicious* (13.33° B), whereas its lowest value was recorded with the fruits of *China* (12.21° B) pear. Of the 6 cultivars, *Flemish Beauty* (8.85%), *Laxton's Superb* (8.88%) and *Starking Delicious* (8.73%) were found equally good statistically for their total sugar contents, while its lowest value was shown by *China* (6.91%). The leakage of electrolytes from membrane into cytoplasm measured in terms of bioelectrical conductance was significantly higher in the fruits of *Starking Delicious* (5.62 m mhos/cm) followed by *China* (5.49 m mhos) and its least value was recorded with *Max Red Bartlett* (4.42

m mhos/cm). The lowest and highest values of starch were registered with *Starking Delicious* (0.87%) and *Laxton's Superb* (1.71%), respectively, at the time of commercial maturity.

The rate of respiration (mgCO₂/kg/h) and ethylene evolution (µl/kg/h) were significantly higher in the fruits of *China* (5 mg CO₂/kg/hr) and 23.58 (ul/kg/h) and *Starking Delicious* (5.62 mg CO₂/kg/h and 23.17 µl/kg/h), while lowest respiration rate (4.42 mg CO₂/kg/h) and ethylene evolution rate (16.00 µl/kg/h) were recorded in *Max Red Bartlett* and *Laxton's Superb*, respectively. Relatively soft cultivars like *China*, *Flemish Beauty* and *Starking Delicious* showed somewhat higher rates of ethylene evolution and respiration which might be the cause for their poor shelf life (Sharma, 1995).

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CHARACTERIZATION OF TRADITIONAL RICE CULTIVARS FROM PLATEAU REGION OF BIHAR AND EASTERN UTTAR PRADESH

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Thirty-five traditional rice cultivars from 4 districts of Eastern Uttar Pradesh and Hazaribagh district of Bihar were evaluated and characterized for 12 agro-morphological traits and high density grain index during 1996 wet season. A large variation was observed for the characters studied. High coefficients of variation was recorded for high density grain index, spikelets/panicle, secondary branches/panicle, panicle weight, and grain weight. Accession Karni (HRC 318) and Jhalore 1 (HRC 336) had extra long kernels (> 7.5 mm); of the two, former showed L:B ratio more than 3.0. High-density grain index was high in Madras (HRC 331), Katika (HRC 326), and Tilakchand-2 (HRC 325). Several accessions were identified as potential donors for improving yield and quality. Of these 9 accessions possessed multiple desirable traits.

Key words : Rice, high density grain index, rainfed ecosystem, germplasm characterization

The success of breeding programme depends on the continuous supply of resource genes for yield components, quality traits and biotic and abiotic stresses. The traditional and locally adapted varieties offer an important gene pool whose vast potential is yet to be fully utilized. With the fast replacement of old land races by the new high yielding varieties, such sources may be lost. Concerted efforts have been underway at CRURRS, Hazaribagh to conserve the enormous genetic diversity in rice especially from rainfed ecosystem. This paper reports the characteristics of new collections from 4 districts of Eastern Uttar Pradesh and Hazaribagh district of Bihar.

The materials for the present investigation comprised thirty-five traditional cultivars collected during 1995 crop season from the Hazaribagh district of Bihar (4) and four districts of Eastern Uttar Pradesh : Ghazipur (7); Jaunpur (2)

Sonbhadra (2); Mirzapur (11) and Varanasi (9). These new accessions were evaluated during the crop season (July-Dec.) of 1996 in three-row plots. Thirty day-old-seedlings were transplanted (single seedling/hill) with plant-to-plant and row-to-row distance of 15 cm each. A basal dose of fertilizer @ 40 Kg N/ha, 40 Kg P₂O₅/ha and 20 Kg K₂O/ha was applied just before transplanting and 20 Kg N/ha was top dressed. Plant protection measures were followed as and when required. Observations were recorded on 10 plants from the middle row. The characters studied were : days to 50% flowering (on row basis); plant height (cm); panicle length (cm); panicle weight (g); primary and secondary branches per panicle (no); spikelets per panicle (no); filled spikelets per panicle (%); 200-grain weight (g); kernel length (mm); breadth (mm), shape (L:B ratio) and high-density grain index (HDI). A

random sample of 200 grains from each accession was used to separate high-density grains using brine solution (1.2 specific gravity) and HDI was computed as suggested by Padmaja Rao *et al.* (1985) excluding chaffs. The range, mean and coefficients of variation were computed using standard statistical methods to assess the variability.

The accessions exhibited substantial variation for all the characters investigated. A wide variation was recorded for HDI, secondary branches per panicle, spikelets per panicle, panicle weight and grain weight, the CV ranging from 29.2 to 122.5 per cent (Table 1). In the previous studies also secondary branches/panicle varied the most (Sinha *et al.*, 1991; Shukla *et al.*, 1996). The rest of the characters had moderate level of variability (CV. 11.3-16.1%). The accession Bakaine 3 (HRC 328) was the earliest to flower (49 days). Plant

Table 1. Range, mean and coefficient of variation (CV) for various agro-morphological characters

Character	Range	Mean $\pm$ SEm	CV %
Days to 50% flowering	49.0-79.0	69.0 $\pm$ 1.8	15.0
Plant height (cm)	78.2 - 119.8	104.1 $\pm$ 1.9	11.3
Panicle length (cm)	16.1-27.7	22.1 $\pm$ 0.2	10.0
Panicle weight (g)	0.8-4.2	2.8 $\pm$ 0.1	30.0
Primary branches/panicle	6.0-12.0	9.8 $\pm$ 0.3	15.3
Secondary branches/panicle	10.3-44.0	28.2 $\pm$ 1.5	31.6
Spikelets/panicle	71.1-246.2	152.6 $\pm$ 8.5	33.0
Filled spikelets/panicle (%)	47.3-97.5	79.1 $\pm$ 2.2	16.1
200-grain weight (g)	2.6-8.0	5.4 $\pm$ 0.3	29.2
Kernel length (mm) (L)	4.3-7.7	5.9 $\pm$ 0.2	15.0
Kernel breadth (mm) (B)	1.9-3.1	2.53 $\pm$ 0.05	11.7
L : B ratio	1.79-3.04	2.32 $\pm$ 0.05	13.1
High-density grain index (%)	0.0-87.5	24.1 $\pm$ 5.0	122.5

Table 2. Accessions possessing useful agro-morphological characters for utilization in the breeding programme

Character	Accessions ^a
Long panicles (= 25 cm)	Kalanamak 1 (332), Tilakchandani 2 (325), Kalanamak (323), Karni 3 (319) Jirabatti 1 (322)
High panicle weight (= 3.4 g)	Pahadidhan (204), Karni 1 (317), Barahasal 1 (202), Bakaine 2 (312), Thupisall (208)
Spikelets/panicle (= 200)	Tilakchandani 1 (324), Karni 1 (317), Jirabatti 1 (322), Pahadidhan (204), Thupisall (208)
Filled spikelets/panicle (= 90%)	Bakaine 2A (316), Bakaine 1A (315), Jirabatti (314), Jirabatti 1 (322), Bakaine 2 (312)
1000-grain weight (= 35 g)	Barahasal 2 (203), Barahasal 1 (202), Jhalore 2 (338), Tilakchandani 2 (325), Adamchini (329)
Long kernels (= 7.0 mm)	Karni 2 (318), Jhalore 1 (336), Barahasal 2 (203), Jhalore 2 (338)
Slender kernels (L : B = 3.0)	Jhalore 1 (336)
High-density grain index (= 75%)	Madras (331), Karhai (327), Tilakchandani 2 (325), Katika (326)

a-Hazaribag Rice Collection number is given in parentheses.

height varied from 78.2 (Adamchini, HRC 329) to 119.8 cm (Tilakchandani-2, HRC 325). Fifteen accessions had long panicles (= 24.0 cm). Kalanamak (HRC 332) had the longest panicles. Panicle weight was high (= 4.0 g) only in three accessions, viz., Pahadidhan (HRC 204), Bakaine-2 (HRC 312) and Karni-1 (HRC 317).

High number of secondary branches per panicle is not a desirable trait since grains borne on them have lower weight than those of primary branches. But secondary branches per panicle varied more and ranged from 10.3 (Bakaine-3, HRC 328) to 44 (Adamchini, HRC 334) while primary branches per panicle varied only from 6.0 (Bakaine 3, HRC 328) to 12 (Bakaine 2A, HRC 316). Five accessions had very high number

Table 3. Characteristics of accessions possessing multiple desirable traits

Accession	50% flow. (days)	Plant height (cm)	Panicle length (cm)	Panicle length (cm)	Panicle weight (g)	Spikelets/Filled panicle (%)	Spikelets (%)	200-grain weight (g)	HDI (%)	Kernel length (mm)
Barahasal (HRC 202)	63.0	107.2	23.2	3.9	168.0	73.9	7.7	0.0	6.20	2.06
Pahadidhan (HRC 204)	79.0	110.0	24.1	4.2	208.0	57.9	6.5	3.5	6.10	2.35
Thupisall (HRC 208)	79.0	112.6	24.2	3.8	200.2	81.5	4.5	0.5	6.50	2.83
Bakaine 2 (HRC 312)	79.0	101.0	24.4	4.0	170.9	91.5	4.8	4.0	6.00	2.31
Karni 1 (HRC 317)	53.0	103.0	23.0	4.0	228.8	83.2	3.9	49.0	6.00	1.94
Jirabatti 1 (HRC 322)	79.0	114.0	25.6	2.7	214.7	94.4	4.5	0.5	5.00	2.17
Tilakchandani 2 (HRC 325)	79.0	119.8	26.1	3.6	139.6	86.8	7.6	75.0	6.50	2.17
Jhalore 1 (HRC 336)	70.0	83.7	20.5	2.5	91.4	72.7	6.6	14.5	7.60	3.04
Jhalore 2 (HRC 338)	79.0	88.6	20.7	76.9	85.9	7.7	30.5	7.10	2.96	

Within parenthesis is Hazaribag Rice Collection number. Under lined values indicate desirable trait (s)

of spikelets per panicle and high percentage of filled spikelets (Table 2). Grain weight is an important yield contributing character especially high grain weight (Table 2). Only 4 accessions had long grains (= 6.61 mm), of which Jhalore 1 (HRC 336) and Karni 2 (HRC 318) had slender grains (Table 2). Most of the accessions (62.9%) had low HDI (< 20%). Nevertheless 6 accessions had reasonably high HDI (= 60%) and 4 accessions showed 30.5-56.0% HDI. The accessions with useful agro-morphological traits have been listed in Table 2. Of these Pahadidhan, Barahasal, Thupisall, Bakaine 2, Karni 1, Jirabatti 1, Tilakchandani 2, Jhalore 1 and Jhalore 2 possess multiple desirable traits (Table 3) and could serve

as good donors for utilization in the hybridization programme.

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C14-8, A HIGH POTENTIAL RICE GENETIC RESOURCE IN BAY ISLANDS

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C 14-8, a very tall, lodging susceptible, stringently photosensitive, traditional *indica* variety assumed to have been introduced from Myanmar about a hundred year back; currently grows over 80% rice growing area in Bay Islands. It produces very low grain yield of 2-2.5 Mg ha⁻¹ indeed extensively preferred by the farmers owing to its wide adaptability across south-, middle- and north Andamans, moderate level of inbuilt tolerances towards biotic and abiotic stresses prevailing in the hot humid tropics of Bay Islands and the amazing character of growing under zero management. Agro- botanical characters of this variety have been profiled in detail in this article.

Located in the emerald blue sea of Bay of Bengal about 1200 km away from mainland India, the humid tropics of Andaman and Nicobar Islands is endowed with maritime climate that offers a conducive agroclimatic for rice cultivation in its low lying lands in the valleys and in the coastal belt. About 3100 mm annual rainfall, 18-31°C minimum and maximum temperature, fertile soil with high organic C, moderate P and K content are the favourable environmental components to support successful rice husbandry. Rice is the second most important crop after plantation species in these islands occupying about 12000 ha of land. Agriculture in Bay Islands is comparatively of recent origin which started as early as 140 years back at the expense of forests. It started with stray cultivation of anonymous varieties, brought about by the convicts during penal settlement. Subsequently, other varieties were also introduced by the refugee settlers during early forties and after wards. Many modern high yielding varieties (HYV) seeped into rice culture system due to massive efforts made by the state government as well as by the Central Agricultural

Research Institute of ICAR during the green revolution era onwards. However, except a few viz. Jaya, Manas Sarovar, Bhavani, IET 5656 and Taichen Sen Yu, majority more wiped out plausibly because of the new environment (?) constrained with heavy disease and insect pressure (hot humid tropical environment seems to be congenial for survival and propagation of disease and insect pests) as well as due to high degree of inbuilt abiotic stresses in the soil, the unpredictable stress dynamics, their interaction with other edaphic factors and compounded climatic hazards. Accordingly, successful transplantation of such varieties and their imbibition across farming community got halted. Interestingly, one cultivar namely C 14-8 which is assumed to have been introduced from Myanmar (the then Burma) during the neonatal stage of agriculture development in these Islands could successfully survive and perpetuated over the time. At present in Bay Islands, this variety occupies more than 80 per cent of the growing area and highly preferred by the farmers. It has been attempted to profile C 14-8 in terms of agronomical traits,

biotic and abiotic stress tolerance norms and to pinpoint the secrets of its high popularity in these islands.

One month old seedlings were transplanted in Crop Research Experimental Farm of Central Agricultural Research Institute at Bloomsdale, Port Blair (Lat. 10°41'13.04" N; long 92°43'30.16" E) during the rice cropping season (May-December) in 1994, '95 and '96. Single seedling per hill was employed in 20 × 15 cm spacing. No fertilisers were applied whereas plant protection measures were adopted. Five random samples from 10 sq m area were used to document the different agrobotanical traits to assess varietal performance. Yield performance of 10 sqm area were extrapolated to calculate per hectare yield.

Field tolerance to biotic stresses viz., disease and insect pests were scored in 0-9 scale following SES, IRTP, IRRI, Philippines 1988. To determine abiotic stress tolerances, young seedlings were grown under hydroponics in Hoagland solution (Yoshida *et al.*, 1976). Different stresses were artificially created by adding salts eg NaCl : CaCl₂ in 1:1 ratio to the level of 8 dSm⁻¹ and 12 dSm⁻¹ (pH 5.0 tolerant check : Pokkali and Nona Bokra; susceptible check : IR 28) for excess salt tolerance; 30 ppm of Al in the form of AlCl₃, 6H₂O (pH 4.0; Biological check : MW 10) for Al toxicity tolerance; 400 ppm of Fe in the form of FeSO₄, 7H₂O and citric acid (pH 4.2, tolerant check : Mashuri, susceptible check : IR 24) for Fe toxicity tolerance and 0.5 ppm of phosphorus in the form of KH₂PO₄ (pH 6.5, Biological check:IR28) for P deficiency tolerance assessment. Alternate day pH adjustment and weekly renewal of Hoagland solution were performed till the date of final observation following Majumder *et al* 1995. To assess drought tolerance, seeds were sown on hilly upland soils under rainfed condition and crops were grown and managed under zero management. Submergence tolerance was scored in farmers' field

(low lying) frequently inundated with flash flood during seedling and active tillering phase.

C 14-8 belongs to *indica* subspecies of *Oryza sativa* L. This is a very tall, highly lodging susceptible (due to its long weak internodes) traditional variety assumed to have been introduced about hundred years back from Myanmar. It is stringently photosensitive flowers only after the first week of November i.e. in short days. Open type plants bear profuse lax tillers. (Table 1). Leaves are very green, low senescent drooping

Table 1. Synoptic dossier of an indigenous cultivar C 14-8 in Bay Islands

Character	Specificity/Magnitude
General feature	
Subspecies	<i>Indica</i>
Type	Traditional
Photosensitivity	Stringently (+)ve
Lodging	Highly susceptible
Plant type	Lax having open tillers
Leaf canopy	Vigorous shading type
Internodes	very long,weak
Regeneration after lopping	Very high
Resurgence after insect pest infestation	Very high
Quantitative trait	
Crop duration (days)	180
Days to initial flowering	140
Days to 50% flowering	153
Plant height (cm)	185
Number of tillers per plant	16.0
Number of ear bearing tillers (EBT) per plant	12.0
Panicle length (cm)	29.8
Number of grains per panicle	153
Spikelet sterility (%)	14.0
100 seed weight (g)	3.3
Yield (tonnes per hectare)	2.4
Harvest index (%)	29.6

type; upper leaves cause considerable shading to the lower ones that obviously hinders photosynthesis and this inhibits realization of full physiological yield potential. Vegetative growth rate is very high; withstands 2-3 lopping which provide good amount of green fodder is an

Despite high disease and insect pests pressure in the congenial hot humid tropical environment of Bay Islands, C14-8 manages to keep yield loss below economic threshold value due to its moderate level of inbuilt tolerances to major insect and disease pests harbouring in Andamans (Table 2). The variety displays high degree tolerance to

Table 2. Biotic and abiotic stress tolerance* profile of C 14-8

Biotic												Abiotic						
Disease*				Insect			Excess salt					Fe toxicity	Al toxicity	P deficiency	Drought	Submergence		Phenotypic index
ShB	Hel	BLB	Blast leaf Neck	SB	LF	GB	V	T	F	M	Seedling g					Active tillering		
4	2	2	5	3	4	6	7	2(3)	4(4)	5(6)	2(5)	2	3	6	2	3	2	6

*ShB : Sheath blight, Hel : *Helminthosporium* leaf spot, BLB : Bacterial leaf blight, Blast: Leaf blast, SB : Stem borer, LB : Leaf folder, GB : Gundi bug, V : Vegetative phase, T : Tillering phase, F : Flowering phase, M : Maturing phase

*Data scored in 0-9 scale following SES, IRTP, IRRRI 1988

*Figures within parenthesis are the tolerance norms at 12 dSm⁻¹ salt stress.

additional quality for being preferred by the local farmers. Vegetative phase is also very long. Resurgence ability of the variety after disease and pest incidences is very high in comparison to modern HYVs.

C 14-8 is a very long duration variety. It takes about 6 months for seed to seed. Vigorous tall plants produce about 16 tillers of which ~75 per cent are ear bearing. Plants bear long panicles and low spikelet sterility which are the desirable characters resting in it. Grains are bold having test weight of about 3.3 g. Under zero management, this variety found to produce 2-2.5 mg ha⁻¹ of brown rice. Harvest index is very low unlike other traditional rice germplasm which is indicative of channelisation of much photosynthate into vegetative parts. The variety is found to be well adaptive across south-, middle- and north Andamans endowed with ~3100 mm erratic rainfall distributed over 8 months, 18-33°C minimum and maximum temperatures, ~8 hours sunshine and of 5-15 kmph wind speed.

salinity (*albiet* in flowering phase it is moderate only), Fe and Al toxicity tolerance but susceptible to P deficiency. Probably due to frequent collision with the abiotic and abiotic stresses prevailing in the Andamans, the variety could develop considerable amount of tolerances during the last hundred years which seems to be the driving force behind its successful culture in Andamans. The amazing ability of this cultivar to grow under zero management and thereby less requirement of labour and efforts to execute the very simple transplanting- harvesting protocol is the major reason for its extensive popularity across farming community. The variety could not be replaced with modern HYV from mainland in spite of state government's multipronged drive including havoc encouragement and incentives. High amount of straw which is recovered upon harvesting is a good cattle fodder provides additional return to the farmers. The variety needs to be improved without making much penalty on the adaptability trait through well framed systematic recombination breeding *in situ* in Bay Islands.

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CHARACTERIZATION OF TORIA GERMPLASM (*Brassica campestris* ssp *oleifera* var. *toria*)

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The short note deals with identification of several promising accessions for different economic traits, viz, days to 50% flowering, maturity, plant height, primary branches per plant, main shoot length, seeds per silique, silique length/breadth, biological yield, yield per plant, harvest index 1000 seed weight and oil content etc. It revealed that potential of existing germplasm in developing high yielding genotypes through hybridization followed by selection to combine the desirable traits of different promising accessions.

Key words : Germplasm, toria, seed yield, oil content, harvest index, variability.

Toria (*B.campestris* ssp *oleifera* var *toria*) belongs to the rapeseed-mustard group which is the second major oilseed crop of India after groundnut. Toria being a short duration crop (70-100 days), is mainly grown as a catch crop in northern India in the states of Punjab, Haryana, Uttar Pradesh, Rajasthan and Madhya Pradesh. It is also suitable for multiple cropping system. Wheat and chickpea can successfully be grown after harvesting of toria. Due to its early maturing nature, it escapes from major pests and diseases of rapeseed-mustard. Further, in Eastern India, particularly in the North-eastern hill Region, Assam, Orissa and parts of Madhya Pradesh (Chhattisgarh, Bastar region) it is grown as a sole crop during *rabi* season.

Germplasm provides the base material for crop improvement. Modern cultivation practices employing the high crop intensity have resulted in the loss of diversity, particularly that of short duration crops. Efforts have been made to preserve the rapeseed-mustard germplasm (Anon. 1983;

Kumar, 1987 and Yadav *et al.* 1997), however, information on evaluation and characterisation of toria germplasm is scanty. Present investigation was undertaken to evaluate the toria germplasm maintained at this centre for yield, yield contributing traits and oil content to assess their potential value in cultivar development programme.

Two hundred thirty lines of toria germplasm, obtained from different centres were grown in an augmented design during *Rabi* 1997-98 at NRCRM, Bharatpur in a two row plot of 3 m length with row to row and plant to plant spacings of 30 and 10 cm, respectively. PT303 and T-9 were used as checks. The observations were recorded on five randomly selected plants for days to emergence, days to 50% flowering, days to maturity, plant height, primary branches per plant, secondary branches per plant, main shoot length, number of siliques on main shoot, seeds per silique, silique length, silique beak length, biological yield, yield per plant, harvest index and

1000 - seed weight. Oil content of 107 lines was estimated by nuclear magnetic resonance.

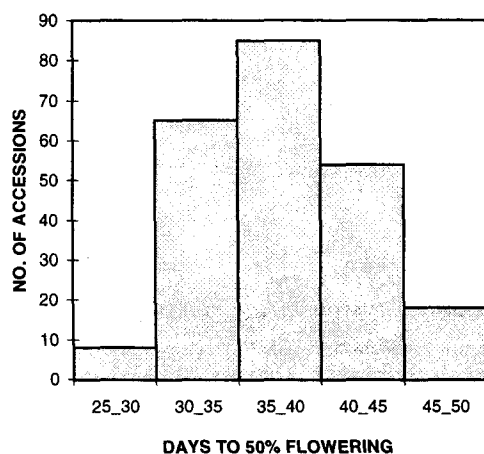


FIG.1.1

All the characters except days to emergence, days to maturity and oil content, showed significant amount of variability in the germplasm (Table 1). Highest variability was recorded for number of primary branches per plant (CV 91.4%) followed by yield per plant, number of secondary branches per plant and biological yield per plant, while lowest variability was recorded for oil content (CV 2.6%) followed by days to maturity and days to emergence.

Days to maturity is an important character in toria. As a catch crop, the varieties maturing in less than 80 days are to be developed to fit into the existing cropping systems. But in the

present germplasm the range for days to maturity was 89-106 days with a low estimate (3.5%) of

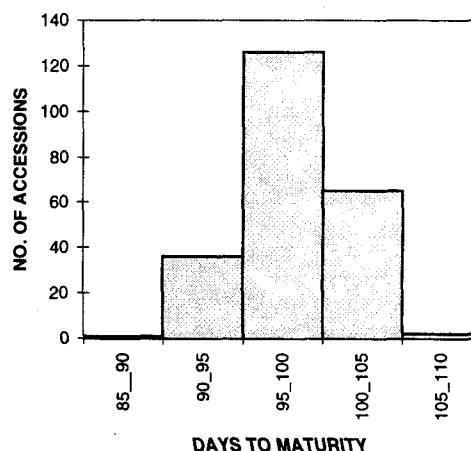


FIG.1.2

co-efficient of variation, indicating the need of further exploration and collection of germplasm for this character for its utilization as a catch crop. On the contrary, days to flowering exhibited wide range with moderate variability. Eight entries flowered in less than 30 days (Table 2). Flowers appeared within 35-45 days in 65 lines while 139 lines (60%) flowered (Figure 1.1). Despite such variability for flowering all lines matured in more than 90 days except NRCT-15 (Fig. 1.2). This may be due to the influence of weather conditions at the time of maturity. A sudden rise in the temperature, perhaps, resulted in fast maturity while cloudy weather prolonged the

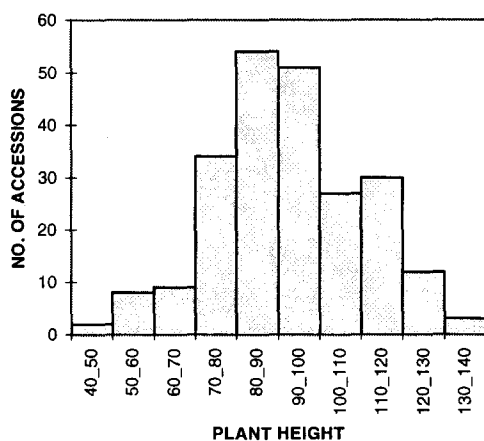


FIG.1.3

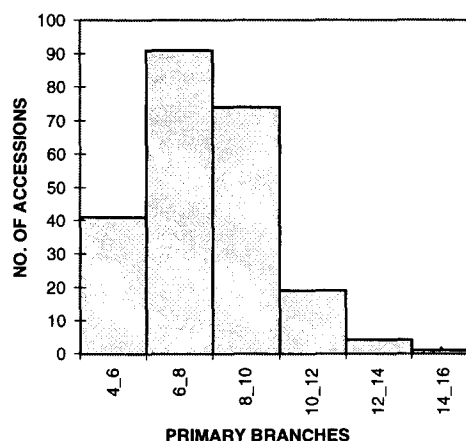


FIG.1.4

duration of maturity. Plants with low height are preferred in toria. Moderate variability with a range of 46.6-133.6 cm was recorded for plant height. Ten lines were of less than 60 cm tall (Table 2, Fig. 1.3). Two promising cultures, namely, NRCT-136 and NRCT-186 were less than 50 cm tall. Variability for number primary branches was greater than for number of secondary branches. On the contrary, range was wider for secondary branches than for primary branches. Majority of lines had less than 10 primary branches (89.6%) and less than 20 secondary branches (93%) per plant (Fig. 1.4, 1.5). Main shoot length and siliquae on main shoot are interrelated traits. Both the characters showed large extent of variability (Table 1).

Majority of the lines fell in two class intervals, i.e. between 30-40 and 40-50 cm for main shoot length (76%, Fig.1.6) and between 20-30 and 30-40 for number of siliquae (70% Fig.1.7) on main shoot. NRCT-5, NRCT-6, NRCT-20, NRCT-96, NRCT-127, NRCT-206 and NRCT-224 were promising lines bearing more than 50 siliquae on main shoot (Table 2). Seeds per siliqua and siliqua length are also inter-related characters. The variability was also almost equal for both the characters as depicted by the estimates of coefficients of variation (Table 1). Only three lines, viz., NRCT-22, NRCT-37 and NRCT-112 had more than 20 seeds per siliqua. Ninety eight lines fell in the range of 10-20 seeds/siliquae (Fig. 1.8).

The longest siliquae were recorded in NRCT-22 (7.7cm) followed by NRCT-112 (7.2cm) and NRCT-37 (6.4cm). Majority (93%) of lines had siliqua length between 4-6 cm (Fig.1.9). Siliqua beak length showed more variability than siliqua length. However, only one line had less than 0.5 cm beak length. 218 lines (95%) had beak length between 0.5 to 1.5 cm (Fig.1.10). Seed weight showed moderate variability (CV 18.7%) and most of the lines had

Table 1. Range, mean and coefficient of variation (CV) for different quantitative traits in toria (*B. campestris* var. *toria*)

Trait	Range	Mean $\pm$ SE	CV(%)	Mean values of Checks	
				PT 303	T9
Days to emergence	3-4	3.4 $\pm$ 0.03	6.9	3	3
Days to flowering	25-46	36.8 $\pm$ 0.31	12.8	33	35
Days to maturity	89-106	98.0 $\pm$ 0.23	3.5	97	99
Plant height (cm)	46.6-133.6	92.5 $\pm$ 0.07	19.2	76.7	89.7
Primary branches/plant	4.2-15.0	8.4 $\pm$ 0.51	91.4	7.4	7.8
Secondary branches/plant	2.2-44.4	11.1 $\pm$ 0.38	51.7	14.9	13.9
Main shoot length (cm)	16.6-63.8	38.9 $\pm$ 0.57	22.1	33.9	38.3
Siliquae per main shoot	13.6-56.0	31.9 $\pm$ 0.62	29.7	24.9	32.7
Seeds/siliqua	9.3-24.2	14.7 $\pm$ 0.15	15.1	15.3	14.8
Siliqua length (cm)	3.6-7.7	4.9 $\pm$ 0.04	12.3	4.8	5.2
Siliqua beak length (cm)	0.4-2.0	1.0 $\pm$ 0.02	25.6	0.9	0.9
Yield/plant (g)	2.1-12.0	4.1 $\pm$ 0.14	52.9	3.8	4.9
Biological yield (g/plant)	4.6-61.2	16.5 $\pm$ 0.56	51.6	14.4	15.5
Harvest index (%)	13.6-47.7	25.5 $\pm$ 0.42	24.8	26.5	31.6
1000-seed weight (g)	1.6-3.6	2.6 $\pm$ 0.03	18.7	2.8	2.7
Oil content (%)	35.7-42.3	40.2 $\pm$ 0.10	2.6	41.7	42.5

less than 3.0 g seed weight (Fig. 1.11). Only eight lines recorded more than 3.5 g seed weight.

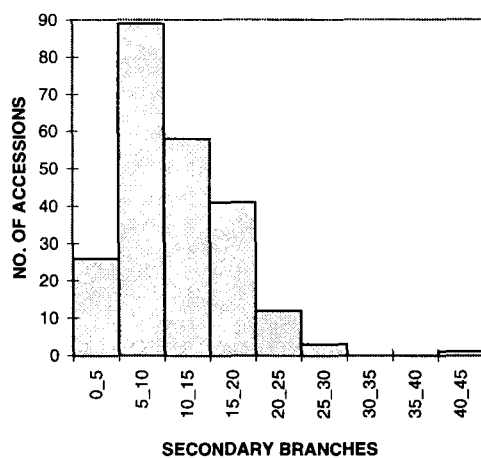


FIG.1.5

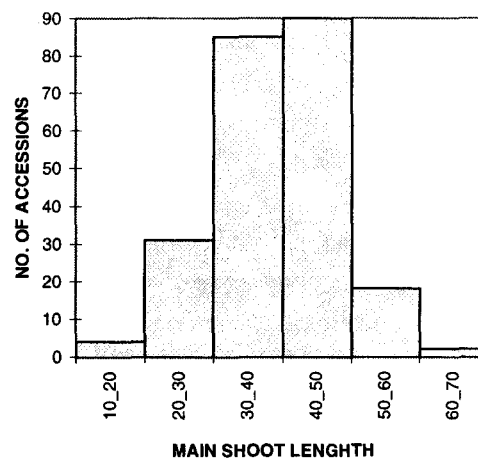


FIG.1.6

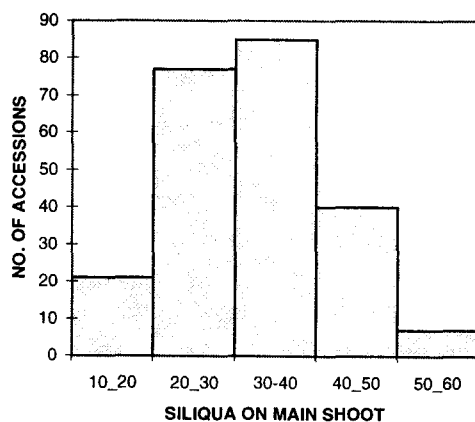


FIG.1.7

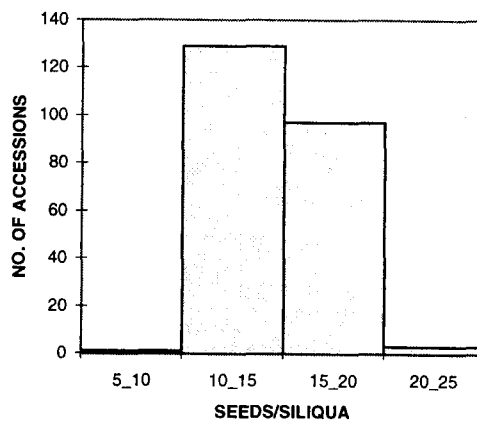


FIG.1.8

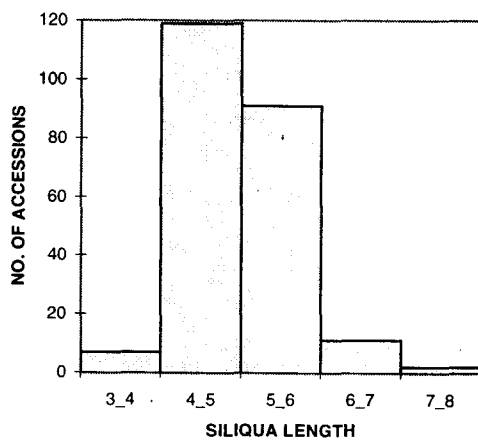


FIG.1.9

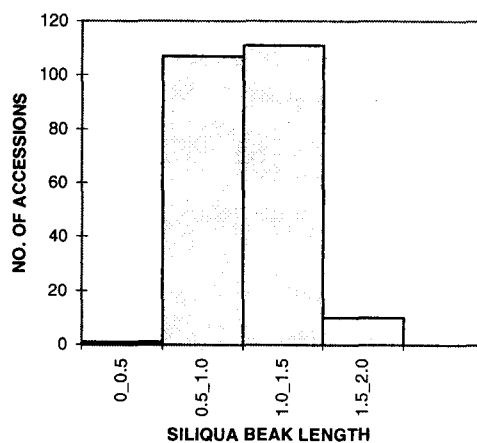


FIG.1.10

It shows the need of further exploration of the germplasm for bolder seeds. Variability for yield per plant was high (C.V. 52.9%), however, only three lines namely NRCT-93, NRCT-120 and NRCT-123 produced more than 10 g per plant,

while 73% lines yielded less than 5.0 g/plant (Fig. 1.12).

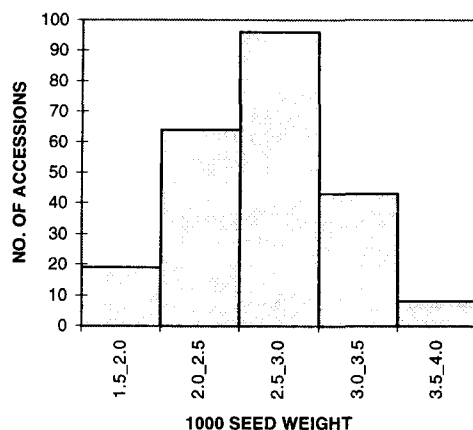
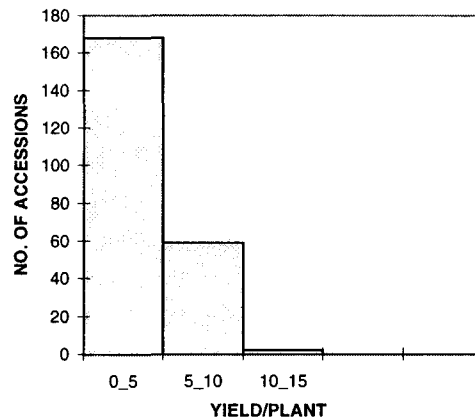
Biological yield has gained much importance in selecting high yielding plant. A high biomass

Table 2. Promising accessions of toria for different economic traits

Trait	Germplasm accessions
Days to 50% flowering (< 30 days)	NRCT-30, NRCT-93, NRCT-131, NRCT-203, NRCT-204, NRCT-205, NRCT-236, NRCT-237
Plant height (< 60 cm)	NRCT-136, NRCT-138, NRCT-154, NRCT-186, NRCT-190
Primary branches/plant (> 12)	NRCT-8, NRCT-95, NRCT-120
Secondary branches/plant (> 25)	NRCT-21, NRCT-120, NRCT-185
Main shoot length (> 55 cm)	NRCT-7, NRCT-31, NRCT-79, NRCT-87, NRCT-96, NRCT-105, NRCT-123, NRCT-127, NRCT-206
Siliquae on main shoot (> 50)	NRCT-5, NRCT-6, NRCT-20, NRCT-96, NRCT-127, NRCT-206, NRCT-224
Seeds/silique (> 20)	NRCT-37, NRCT-22, NRCT-112
Silique length (> 6 cm)	NRCT-5, NRCT-17, NRCT-22, NRCT-30, NRCT-37, NRCT-40, NRCT-45, NRCT-112, NRCT-147, NRCT-185, NRCT-229.
Biological yield/plant (> 40 g)	NRCT-23, NRCT-74, NRCT-109, NRCT-111, NRCT-120, NRCT-127
Harvest index (> 40%)	NRCT-29, NRCT-100, NRCT-141, NRCT-150, NRCT-235

with high harvest index is desirable for a high yielding genotype. In the present study, biological yield, showed high variability, but variability for harvest index was low, indicating thereby the need of improvement of harvest index, particularly that of high biomass genotypes, so the larger portion of the photosynthates could be mobilised to the seeds. Fig. 1.13 represents the distribution of germplasm lines for biological yield in a wide range of class intervals. The range observed in the germplasm for harvest index was 13.6-47.7. One hundred thirty three accessions showed the harvest index between 20-30% (Fig. 1.14). Five lines namely NRCT 29, NRCT 100, NRCT 141, NRCT 150 and NRCT 235 showed more than 40% harvest index (Table 2). However, these lines were poor seed yielders. It was observed that these lines were poor in biomass, therefore, it would be appropriate to improve the biomass of those lines which had high harvest index. Oil content could be analysed only in 107 lines. Least variability was observed for oil content (CV 2.6%), with a range of 35.7 to 42.3%, indicating the need of further exploration of germplasm for oil content.

Several promising accessions were identified on the basis of present study for different economic traits (Table 2). It reveals the potential of existing

**FIG.1.11****FIG.1.12**

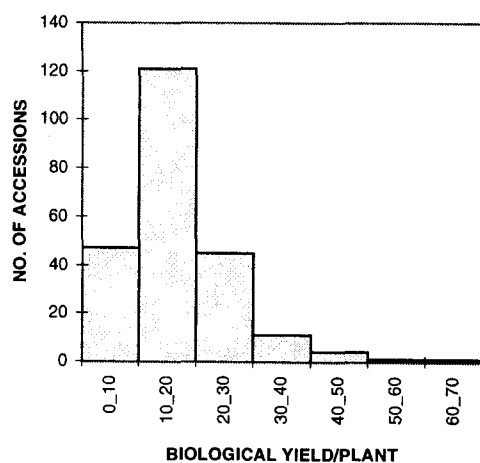


FIG.1.13

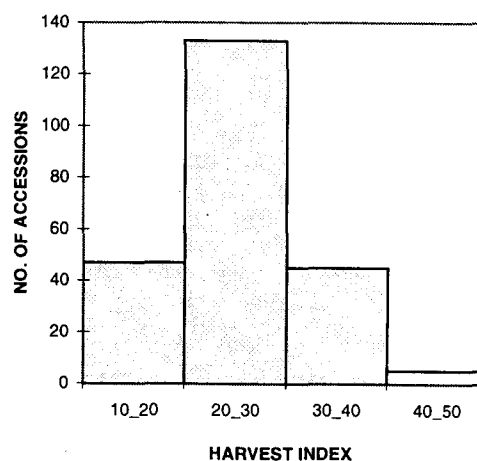


FIG.1.14

germplasm in developing high yielding genotypes through hybridization followed by selection to combine the desirable traits of different promising accessions. However, further exploration of germplasm is required for high oil and early maturing types.

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GENETIC DIVERSITY IN SOYBEAN

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Three hundred exotic accessions of soybean (*Glycine max* L.) from various countries were evaluated for several quantitative characters. The accessions were grouped into five clusters. There was no correspondance relation between the geographic distribution and their inclusion in a particular cluster. Genetic divergence analysis showed that the maximum distance was between II and V followed by I and IV cluster. Based on cluster means it is concluded that the crosses among the accessions of the cluster I, III and IV might be useful. The accessions viz. EC-2542, EC-9309, EC-11740-A, EC-11741-A, EC-14472, EC-14474, EC-26692, EC-34041, EC-34146-B, EC-37004, EC-37005 and EC-37066 showed desirable characteristics. These accessions can be utilised in hybridization programme to achieve high levels of yield and oil.

Key words : Soybean, genetic diversity, germplasm

The germplasm of soybean were introduced in India at large scale during mid seventies. The area under soybean has increased 1500 folds since 1967-68 and 40 soybean varieties have been released for its commercial cultivation, so far. Broad genetic base is an important aspect for any breeding programme. Genetic diversity among parental lines is also an important factor for developing a variety. Only very meagre information is available for genetic diversity in this crop for Vidarbha region of Maharashtra. Genetic divergence analysis which quantify the differences among the quantitative characters is an efficient method to evaluate genetic diversity. Therefore, the present study was carried out using non hierrarchical euclidean cluster analysis to classify 300 accessions of soybean into group on the basis of quantitative characters.

The experimental material comprised 300 exotic accessions of soybean from China, USA, Brazil, Canada, South Africa, Australia, Japan, Nepal, Italy, UK, Germany, Hungary, Argentina, Taiwan and Russia. These were grown at Experimental Farm, National Bureau of Plant Genetic Resources (NBPGR), Regional Station, Akola during the Kharif, 1996, in augmented block design, using two checks i.e. Bragg and MACS-13. The row length was three meter long and spaced 60 cm apart. Observations were recorded on days to 50 per cent flowering, days to maturity, number of leaflets, plant height, seeds/pod, yield/plant(g), 100-seed weight(g) and oil content. Non hierrarchical euclidean cluster analysis was used for accessing the genetic divergence among the 300 accessions of soybean following method as suggested by Spark (1973). The accessions were grouped into five clusters.

In this present study, 300 accessions of soybean were classified into 5 clusters (Table 1).

Table 1. Grouping of 300 accessions of soybean in different clusters

Cluster	No. of entries	Source country
I	126	China, Australia, Nepal, S. Africa, Canada, Germany, Italy, Hungary, Taiwan, Japan, USSR
II	84	China, USA, Brazil, Australia, Japan, Nepal, Italy, Argentina, Hungary, Germany, Taiwan
III	44	China, USA, Japan, Australia, Germany, Nepal, Italy, UK, Hungary, USSR
IV	45	China, USA, Canada, S. Africa, Australia, Japan, Hungary, USSR
V	1	USA

The clustering pattern in the present study indicated that the genotypes from one source country were distributed in to different clusters. This suggests the lack of distance build up of geographical diversity. The average intra and inter cluster distances have been presented in Table 2. Average inter cluster distance values ranged from 2.57 to 17.70 (Table 2). The maximum distance

Table 2. Inter and intra-cluster values in 300 exotic accessions of soybean

	I	II	III	IV	V
I	0				
II	2.69	0			
III	3.23	3.13	0		
IV	3.17	2.74	2.57	0	
V	17.66	17.70	17.48	17.49	0

$\bar{D} = 5.85$

existed between cluster II and V (17.70), however, cluster V showed much distance with cluster I, II, III and IV. Intracluster distance was 0 for all the clusters indicating similarity within the clusters. Cluster I contained the maximum number of

accessions (126). These accessions were early flowering and maturity (28-32 days to flowering and 67-83 days maturity), dwarf to medium plant height, medium seed size and moderate oil content.

Table 3. Cluster means for eight characters in 300 exotic accessions of soybean

Character	I	II	III	IV	V
Days to 50% flowering	30.01	39.51	36.82	44.02	39.00
Days to maturity	78.37	93.27	90.61	101.84	97.00
No. of leaflets	3.00	3.00	3.00	3.00	3.00
Plant height(cm)	36.62	61.38	69.83	45.97	58.00
Seeds/pod	2.10	2.10	2.51	2.09	2.80
Yield/plant(g)	3.16	3.72	12.99	6.82	4.70
100-seed weight(g)	9.58	6.87	10.21	10.68	11.80
Oil (%)	18.60	17.30	19.07	19.49	20.00

Cluster II comprised 84 accessions contained late flowering, medium maturity, tall, small seed size, low yielder and low oil content. Cluster III contained 44 accessions showed highest yield/plant (12.99 g) as compared to all clusters. Cluster IV had 45 accessions showed late flowering and maturity, medium plant height, medium seed size and high oil content (19.49%).

The utility of classifying germplasm for selection of diverse parents for hybridization has long been appreciated (Bhatt, 1970). The accessions grouped in cluster I and IV followed by I and III were wide apart for days to flowering, days to maturity, plant height, yield/plant. Cluster III showed highest genetic divergence for yield/plant, however cluster IV showed highest genetic divergence for oil content. High oil can be harvested by obtaining high yield with the condition that a variety must have good oil content. Obviously, the crosses between accessions of cluster I, III and IV might be useful for obtaining the transgressive segregants in segregating generations. Apart from high genetic divergence, the performance of the accessions for characters such as early flowering and maturity, plant height,

yield/plant and seed size should be considered prior to their inclusion in breeding programme.

Soybean is believed to be of native of south-east Asian origin. Nagata (1959, 1960) suggested that the soybean originated in China proper, probably in the north and central regions. The soybean germplasm originally disseminated from China to rest of the world. The genetic divergence of the accessions in this study is in no way influenced by geographic distribution. There are various examples of accessions having same origin but falling in different groups. Griffin and Palmer (1995) studied genetic distance among Asian gene centres and North American cultivars based on gene frequencies for all of the *G. max* and the *G. soja* accessions. Distances among *G. max* and *G. soja* groups generally were smaller than between *G. max* and *G. soja* groups. The *G. max* cultivars developed by selection from plant introductions were closest to the accessions from China, Japan, Korea and the Man Sib region. It indicates no influence on geographic distribution of the soybean germplasm lines.

The accessions EC-2542, EC-9309, EC-11740A, EC-11741A, EC-14472, EC-14474, EC-26692, EC-34041, EC-34146B, EC-37004, EC-37005 and EC-37066 showed desirable characters including oil content. These accessions can be utilised as parents in the hybridization programme.

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EVALUATION OF MUNGBEAN GENOTYPES FOR RESISTANCE TO POWDERY MILDEW

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Two hundred and sixty nine mungbean genotypes were tested for reaction to powdery mildew (*Erysiphe polygoni* DC) under natural epiphytotic conditions. Genotypes DHMC 9601, DHMC 9602 and DHMC 9603, DHMC 9604 were rated as high resistant and resistant respectively where 3 genotypes (DHMC 9605, DHMC 9606 and DHMC 9607) were scored as moderately resistant. These can be utilized in mungbean breeding programme.

Key words : Greengram, *Vigna radiata* L. Wilzek, powdery mildew *Erysiphe polygoni* DC. resistant sources

Powdery mildew (*Erysiphe polygoni* D.C.) is one of the major diseases predominant in most mungbean (*Vigna radiata* L. Wilzek) growing areas (Park and Yang, 1978). In India, it is a serious problem in Southern and Central regions (Grewal, 1978). The grain yield reductions could range from 20 to 40 per cent (Legaspi *et al.*, 1978) if the infection is at pod formation stage. However, there can be complete loss of the crop when the disease occurs at the seedling stage. The powdery mildew resistance in mungbean is reported to be governed by two dominant genes designated as Pm-1 and Pm-2 (Reddy, *et al.*, 1994). There can be additional genes for resistance in mungbean other than the two identified earlier. Thus there is a need to identify additional sources showing high degree of resistance to powdery mildew, not only for studying the genetics of powdery mildew but also for developing powdery mildew resistant cultivars through introgression of resistance genes.

The present study included screening of 269 mung genotypes maintained at IARI, Dharwad,

for their reaction to powdery mildew under natural epiphytotic conditions in *kharif* 1996. The highly susceptible cultivar, K851, was planted after every ten test entries in an augmented design. Each entry was planted in single row plots, 3 m long and spacing of 0.45 m between rows and 0.1 m between plants. Visual observation on powdery mildew incidence was recorded at maximum pod formation stage adopting 0-5 scale (Reddy, *et al.* 1994) based on per cent leaf area infected.

The promising lines showing resistance/moderately resistant reactions were reexamined for powdery mildew incidence in *kharif* 1998. The test entries were inoculated by shaking conidia from heavily infected leaves of the highly susceptible cultivar (K851) over young and older leaves at seedling and flowering stage. Visual scoring for powdery mildew was recorded as suggested above.

The lines showing resistance/moderate resistance were also evaluated for few important agronomic characters in *kharif* 1997. The material was grown in Randomised Block Design replicated

Table 1. Performance of mungbean genotypes resistance/moderately resistant to powdery mildew, *khari*, 1997

Genotype	Grain Yield per plant (g)	100 seed weight (g)	Days to flowering	Days to maturity
Highly Resistant				
DHMC 9601	7.51	4.3	42	69
DHMC 9602	10.73	4.8	40	69
Resistant				
DHMC 9603	7.95	4.4	40	60
DHMC 9604	10.82	2.7	38	62
Moderately resistant				
DHMC 9605	6.16	2.2	43	71
DHMC 9606	9.42	2.3	42	70
DHMC 9607	8.13	2.3	44	72
Checks				
PS 16	5.70	2.9	37	60
Chinamung	8.28	4.9	38	62
Pusa 105	9.56	2.9	45	72
ML 5	8.24	2.8	43	70
ML 131	8.33	2.8	39	65

two times. Each entry was planted in single row plots in each replication, 3 m long, 0.3 m between rows and 0.1 m between plants. Observations were recorded on five competitive plants selected randomly from each plot in each replication.

Among the genotypes screened for powdery mildew, two genotypes consistently rated highly resistant (R_0), two resistant (R_1 or R_2) and three moderately resistant (MR). The remaining 141 lines were rated susceptible (S) while 121 lines showed highly susceptible (HS) reaction.

The performance of the resistant to moderately resistant genotypes for days to flowering, days to maturity seed size and grain yield per plant is given in Table 1. The resistant sources identified can be used in the mungbean breeding programme to enhance the productivity of genotypes in an economically and environmentally sustainable way by developing cultivars resistant to powdery mildew.

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AGRO-BIODIVERSITY AND CROP GENETIC RESOURCES IN NORTH-WESTERN HIMALAYAS

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Western Himalaya contributed a great deal in conservation of crop genetic resources such as amaranths, chenopods, buckwheat, maize, wheat, finger millet, *Echinochloa frumentacea*, rice, lentil, *pyrus*, *prunus*, *sorbus*, *Rubus*, *Ribes*, *Hordeum*, *Allium*, *Lepidium*, *Carum*, *Cicer*, *Cucumis* etc. Extent of variability in some of these crop has been depicted in this paper.

Key words : Agro-biodiversity, economic plants, NW Himalayas

The Himalayan ranges are about 2500 km long extending 73° to 93° East longitude and from 27°N to 37° North latitude, and covering an area of approximately 236000 sq. km. The entire region is endowed with a wide range of physiography, climate, soil and biological wealth. It has a large altitudinal range (300-8000 m), with a rich diversity of habitats providing varied micro climate and ecological niches not only for plants but also for humans. The western and the eastern flanks of the Himalayas are different. The Western Himalayan ranges are much wider and cooler with drier climate. In contrast, the eastern ranges are among the wettest regions of the world with high biodiversity (Khoshoo, 1992). The north western fringe include Kashmir, Himachal Pradesh and Uttarakhand (U.P.). The climate in north western himalaya ranges from sub tropical to arid shivaliks (subtropical); H.P., Uttarakhand (warm temperate, upper reaches approaches arctic); Kashmir Himalaya (dry temperate approaching arctic in Ladakh). Following Bagnolus and Gaussen (1957), the climate of the area is xerothermic and Sub Mediterranean. The precipitation however

increase with increase in altitude upto certain point beyond which it decreases. Most of the precipitation at higher reaches is in form of snow which plays an important role in maintaining the moisture balance during the summer months when there is little rainfall. The western ranges have a vegetation, which is cold loving and drought resistant. There are large gregarious populations of conifers like the pines, deodar, fir and spruce. The native population rely on number of unconventional food plants such as *Vigna vexillata* (Soplong), *Chenopodium* (Bathua), Buckwheat (Phaphar), Amaranth (Chaulai), Mushrooms etc because of small land holding and unaffordable optimum agricultural inputs. (Samant and Dhar 1997).

Centre of diversity of major crops in North Western Himalayas

India is one of the important centers of diversity of having contributed 167 species of plants whose origin and diversity is in this country. Within India there are eight sub-centres, of which three fall in the Himalayan belt. The Western

Himalaya has contributed species of the genera of *Pyrus*, *Prunus*, *Sorbus*, *Rubus*, *Ribes*, *Hordeum*, *Elymus*, *Eremopyrum*, *Avena*, *Aegilops*, *Allium*, *Lepidium*, *Carum*, *Linum*, *Cicer*, *Cucumis* (Arora and Nayar, 1984).

Genetic wealth of agri-horticultural crops in N.W. Himalayas

A total number of 162 species under 122 genera representing 53 families have been recorded by Negi and Pant (1994) from UP Himalaya as shown in Table 1. The dominant families of genetic wealth are Fabaceae (21), Cucurbitaceae (14), Brassicaceae (12), Poaceae (11), Rutaceae (8), Rosaceae (7), Solanaceae (7), Apiaceae (7) and Amaryllidaceae (4).

Table 1. Economic plant wealth of agri-horticultural crop groups in U.P. hills

S.N.	Crop Groups	Species No.
1.	Cereals	05
2.	Pseudocereals	06
3.	Minor millets	06
4.	Pulses	17
5.	Oil yielding crops	09
6.	Vegetables	27
7.	Salad	07
8.	Spices & condiments	17
9.	Fibres	07
10.	Semi domesticated	11
11.	Narcotics	02
12.	Washing detergents	01
13.	Bevarages	01
14.	Medicinal & Aromatic plants	12
15.	Horticultural & other fruit yielding plant material	34
Total		162

Wild relatives of cultivated plants

Among the wild relatives of cultivated plants, a rich diversity 125 species (Table 2) in the

Table 2. Distribution of wild relatives of crop plants in the North-western Himalaya

Crop Group	Genera represented	Species represented (no.) Western Himalaya
Cereals & millets	15	29
Legumes	7	9
Vegetables	17	25
Fruits	25	37
Oilseeds	3	6
Fibers	6	4
Spices & condiments	8	10
Misc.	9	5
Total species diversity		125

Western Himalaya (Arora and Nayar, 1984). Most of wild relatives provide a donor gene for wider adaptability, vigorous growth and resistance to major diseases and pest. Hence the native diversity can be utilized as a material for breeding and selection. To assess their existing economic value, ethnobotanical observations, quantitative data on the diversity and abundance of the species need to be intensified.

Needs for collection of crop diversity

The significant changes in the land use pattern are predominantly influenced by the modern agriculture and habitat loss. The recently occurred landslides in Rudraprayag and Malpa are example of it. This had led to the loss of habitat consequently depleted the wide range of biological resources. Estimates of the rates of species extinction vary widely but the steady loss of biodiversity at every level is widely acknowledged. Survey conducted by Maikhuri *et al.*, in the Alaknanda catchment areas of North Western Himalaya revealed that the area under cultivation of traditional crops has declined at an alarming rate. In the last two decades area under *Hordeum* himalayans, *Secale cereale* and *Fagopyrum* spp. has

been reduced by 80-85 per cent. Similarly the horsegram, and barnyard millet declined by 60-75 per cent in the lower altitude of 560-1500 m amsl. Cultivation of *Perilla frutescens* and *Hordeum himalayans* has decreased rapidly and both these crops are at the verge of extinction in this area.

Similarly Atkinson 1885 described 48 varieties and stated thousand non descriptive varieties of rice occurs in U.P. hills but now its limited upto 10-12 type only. Thus the genetic base of rice is narrowing down.

Collecting crop genetic resources from N.W. Himalayas

Exploration were undertaken during 1978-85 by various teams of scientists and collections were made from eight districts of U.P. hills as shown in Fig 1. About 5000 accessions of various crops

were collected from this region by VPKAS, Almora. The crop wise details of local landraces presently maintained at this institute are given in Fig. 2.

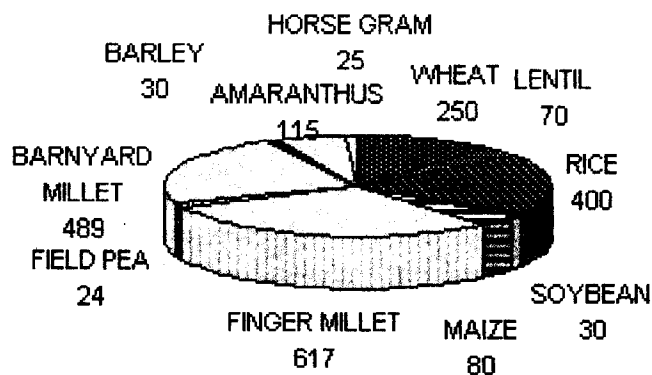


Fig. 2. Details of local collections of germplasm maintained at VPKAS, Almora

Besides this, the indigenous germplasm resources from other regions and the exotic germplasm were also received in form of National and International

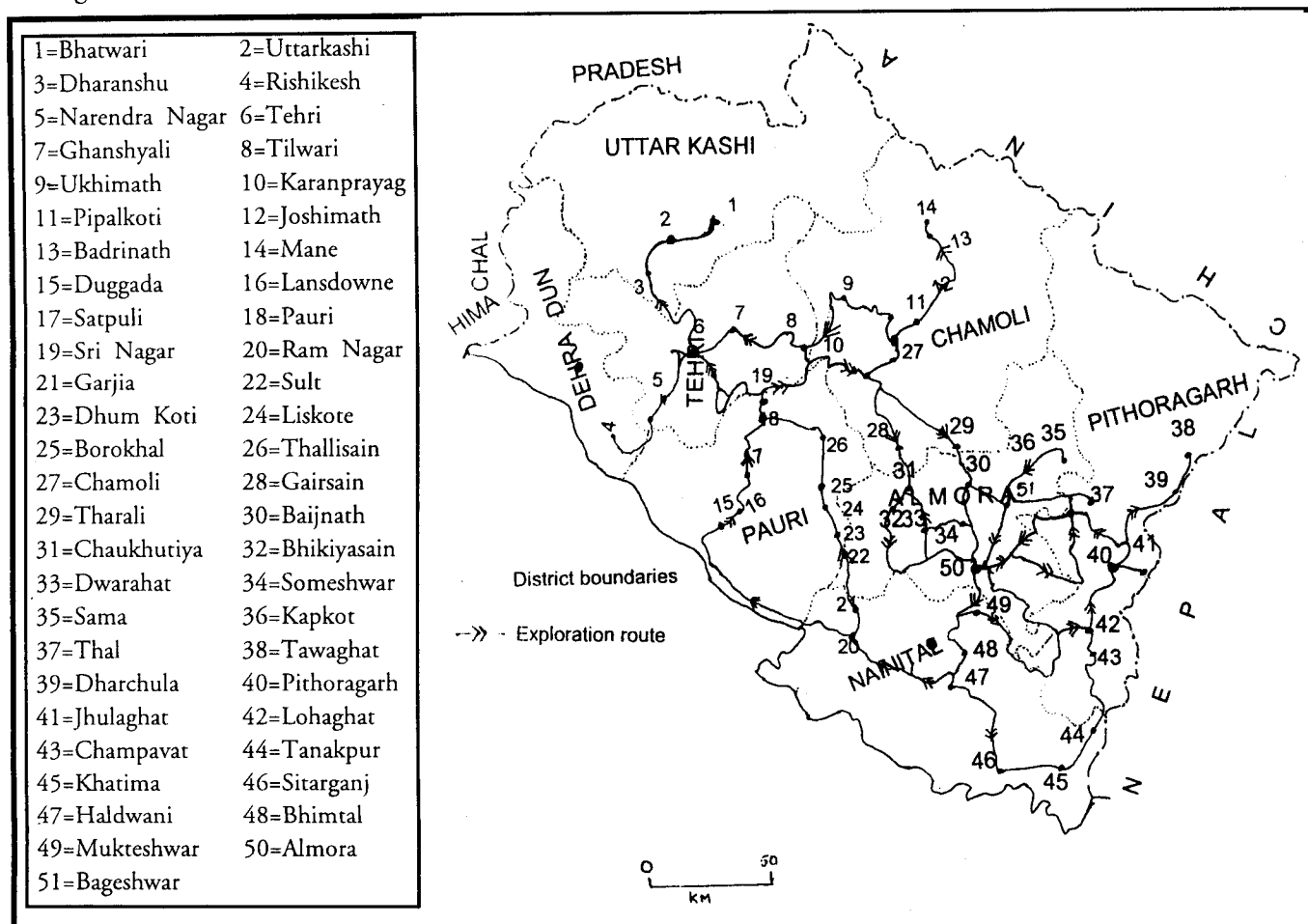


Fig. 1. Route map for the germplasm collection from U.P. hills

Nurseries and trials from AICRP/NBPGR.

Extent of variability in local collections

Maize

On the basis of variation in 75 per cent days to silk, 75 accessions were grouped into 4 distinct maturity classes namely late (64-67 days), medium (60-62 days), early (49-53) and very-early (40-42 days). (Mani, 1996) Most of the collections belonged to their early maturity (41%) or very early groups 26 per cent, whereas 26 per cent collections were medium in maturity and only 5 per cent were late maturity types. The range of variability in the maturity duration thus suggested that preference for shorter maturity groups in the U.P. hill. The range and mean of 75 genotypes for 10 characters under 4 maturity groups showed in Table 3.

280 local collections of wheat from U.P. hills (VPKAS, 1980). All the cultures have been classified into different categories viz., intensity of coleoptile colour, awn, leaf auricle pigmentation, early growth habit, leaf length and width and grain colour, texture and size.

Madira (*Echinochloa frumentacea*)

Nine hundred fifty five accessions including local collections were evaluated for various agromorphological characters and disease and pest incidence (VPKAS, 1981). The data are summarized in Table 4.

Finger millet

Nine hundred eighty eight local collections of ragi were grouped into three categories on the basis of ear shape (open, semi compact and compact) and pigmentation at internode. A wide

Table 3. Mean and ranges for different characters under four maturity groups in maize

Sl. No.	Character	Late	Medium	Early	Very early
1.	Days to silk (75%)	65.0 (64-67)	60.9 (57-63)	51.2 (48-55)	43.3 (38-47)
2.	Plant height (cm)	233 (204-288)	237 (191-277)	205 (154-237)	181 (152-232)
3.	Ear length (cm)	132 (99-207)	135 (77-181)	106 (74-136)	81 (45-128)
4.	Ear length (cm)	171.1 (15.4-18.4)	15.5 (13.2-17.0)	13.4 (11.2-14.8)	12.7 (9.0-15.2)
5.	Ear girth (cm)	13.6 (13.2-14.0)	13.0 (11.4-14.2)	12.4 (10.6-15.5)	12.1 (9.0-14.4)
6.	<i>H. turcicum</i> * (1-5)	2.4 (2.0-2.5)	2.1 (1.5-2.8)	2.1 (1.5-2.8)	2.0 (1.5-3.0)
7.	<i>H. maydis</i> * (1-5)	2.1 (2.0-2.5)	2.0 (1.5-2.5)	2.1 (1.5-2.8)	2.0 (1.5-3.0)
8.	Plant aspect** (1-5)	2.5 (2.5-2.8)	2.5 (2.3-3.0)	3.1 (2.0-4.0)	3.1 (2.8-4.8)
9.	Ear aspect** (1-5)	2.5 (2.5-2.5)	2.5 (2.0-2.8)	2.3 (2.3-2.5)	2.7 (2.7-3.5)
10.	Husk cover** (1-5)	2.3 (2.3-2.3)	2.4 (2.3-2.8)	2.6 (2.5-3.0)	2.7 (2.5-3.3)

* 1 Resistant, 5 Highly susceptible; ** 1 best, 2 poor

Wheat

High variability for days to 50 per cent flowering (118-151), days to maturity (163-177) and plant height (100-150 cm) was recorded in

range of various for the various characters among these categories were recorded as shown in Table 5. Out of these IE 99-1 was found free from both neck and finger blast.

Table 4. Frequency distribution of cultures in various classes and range of expressions in Barnyard millet (*Echinochloa frumentacea*)

Sl. No.	Plant height		Maturity		Ear length		Ear compactness		Ear nature		Ear colour		Smut disease		Stem borer	
	Class	Freq	Class	Freq	Class	Freq	Class	Freq	Class	Freq	Class	Freq	Class	Freq	Class	Freq
1.	Below 110	206	Below 100	99	Below 10	15	Compact	323	Erect	879	Purple	290	0	-	0	721
2.	111-130	132	101-105	248	11-15	356	Intermediate	551	Drooping	76	Light purple	619	3	20	1	176
3.	131-150	86	106-110	345	16-20	386	Lax	81			Purple green	46	5	385	2	58
4.	151-170	395	111-115	222	21-25	152							7	316	3	-
5.	171 and above	136	116 and above	4	26 and above	41							9	234		
Range	60-230		98-119		7-28											

Table 5. Variability in local collected ragi (*Eleusine coracana*) germplasm

Group (ear shape)	Number	50% heading		Plant height		Number of effective tillers/plant		No. of fingers per ear		Finger length of the main ear (cm)	
		Range	Mean	Range	Mean	Range	Mean	Range	Mean	Range	Mean
Open with pink internode	26	66-80	71.23	75-130	100.95	2-4	2.74	5-9	6.84	6-11	7.71
Open with greenish white internode	91	62-99	71.88	64-130	99.66	2-4	3.05	5-12	7.58	6-11	10.35
Semi compact with pink internode	83	57-92	70.89	60-135	97-72	2-5	2.60	4-9	6.75	4-12	6.91
Semi compact with greenish white internode	127	58-109	74.94	65-130	94-40	1-4	2.67	4-11	6.94	5-16	7.35
Compact with pink internode	336	51-108	72.42	50-140	95.64	1-5	2.94	4-12	7.35	3-11	6.27
Compact with greenish internode	325	52-109	70.92	60-130	88.74	1-6	3.06	6-11	6.82	3-15	6.81
Range	988	51-109	71.75	50-140	96.1	1-6	2.89	4-12	7.85	3-18	7.88

Table 6. Details of varieties developed at VPKAS, Almora through direct utilization of germplasm collected from U.P. hills

Name of the crop	Name of the variety	Year of release	Area of adaptation
Rice	VL Dhan 206	1983	U.P. hills (spring sown)
Finger millet	VL Mandua 204	1987 UPSVRC	U.P. hills
	VL Mandua 124	1989 UPSVRC	U.P. hills
Barnyard millet	VL Madira 8*	1978 UPSVRC	U.P. hills
	VL Madira 21	1989 UPSVRC	U.P. hills & plains
	VL Madira 29	1986 CVRC	All India except Tamil Nadu & Andhra Pradesh
Lentil	VL Masoor 1	1981 UPSVRC	U.P. hills
	VL Masoor 4	1991 UPSVRC	U.P. hills
Soybean	VL Soya 2	1989 CVRC	N-W. hills
	VL Soya 21	1995 UPSVRC	U.P. hills
Horsegram	VL Gahat 1	1983 UPSVRC	U.P. hills
Rajmash	VL Rajmash 63	1978 UPSVRC	U.P. hills

*Denotified

Rice

Four hundred twelve accessions collected from U.P. hills were evaluated for 13 qualitative characters and 12 quantitative characters. The range of variation was as follows, leaf colour (green 350, light green 20, purple margin 41 and purple line 1); basal leaf sheath colour (light green 350, green 22, purple line 37, light purple 3); collar colour (light green 388, purple 24); awn (presence of awn 126 and absence of awn 286); and panicle exertion (fully exerted 320 and

partially exerted 91). Among the quantitative characters following range was observed: days to 50% flowering, (73-108 days), number of tillers per plant (3-14) panicle per plant (2-10) plant height (73-135 cm), primary branches per panicle (95-111), secondary branches per panicle (3-41), grains per panicle (15-64) paddy length (7.2-10.86 mm), paddy width (2.31-4.28 mm) and yield per plant (1.18-11.95).

Lentil

A wide range of variability was recorded in local collection of lentil viz., days to flower initiation (88-109 days), days to 50 per cent flowering (98-117), days to maturity (165-176 days), 100 seed weight (1.56-4.01 g), plant height (23.1-35.1 cm), height of lowest pod from the ground (7.1-12.1 cm), number of pods per plant (12-55) and yield per plant (5.7-2.13 g).

Apart from the above mentioned crops, the variability in characters such as plant height, inflorescence and grain colour in amaranth; seed shape size and colour in soybean and petiole colour in colocasia was also observed.

During the evaluation of local germplasm, the promising lines were identified and released for cultivation in U.P. hills or N.W. hills (J & K, H.P. and U.P. hills) by UPSVRC and CVRC. The details are given in Table 6. Beside this several of the landraces and traditional cultivars have been utilized in the varietal improvement programmes of V.P.K.A.S., Almora.

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EVALUATION OF SOME DASHEEN TYPE COLOCASIA (*Colocasia esculenta* var. *esculenta*) UNDER BIHAR PLATEAU REGION

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A collection of 30 accessions of less diversified group of Dasheen type *Colocasia* (*Colocasia esculenta* var. *esculenta*) have been made from fourteen different locations of the country and were evaluated under field trial for growth, tuber yield with its attributes and qualitative parameters during *kharif* seasons of 1994, 1995 and 1996. Wide variations in plant height, leaf length/breadth ratio, sheath length, tuber yield, dry matter(%), digestible starch content (%), protein content (%), oxalate content (%) and in organoleptic test were observed. On the basis of tuber yield and qualitative aspects, three distinct types viz. E.Ac.-1, E.Ac.-20 and E.Ac.-26 were identified for commercial cultivation for this region. These could also be utilized as donor germplasm in crop improvement.

Key words : Dasheen, *Colocasia esculenta* var. *esculenta*, evaluation, characterization

Dasheen type colocasia is an important tuber crop used as vegetable in southern part of Bihar. This clonally propagated crop (through tubers) comes under less diversified group of tuber crops, and is less exploited for improvement, inspite of its high yielding ability. Hence, the collected germplasm were evaluated to identify promising lines for crop improvement.

Thirty Dasheen type colocasia germplasm collections from fourteen different locations of the country (Table 1) were evaluated at Department of Horticulture, Birsa Agricultural University, Ranchi during *kharif* seasons of 1994, 1995 and 1996. For evaluation seed materials (side tubers/cut tubers) of each accession was planted in 25-30 cm deep trenches spaced at 75cm with 60cm space between plant to plant within the rows in a plot size of 3m × 2m. Each plot accommodated 20 plants. The experiments were laid out in Randomized Block Design with

three replications. The required package of practices were followed for each treatment with an uniform fertilizer dose of 120 kg N: 80 kg P₂O₅ : 100 kg K₂O with 20 t of FYM per hectare basis were applied during growing seasons each year. Observations on growth attributes viz., plant height (cm), number of leaves, number of tillers/suckers per plant, petiole length (cm), sheath length(cm), leaf length and breadth (cm); yield and its attributes viz., tuber yield (t/ha), corm and cormel length and width (cm) as well as weight (g) and number of cormels were recorded. For qualitative aspects the observations recorded included dry matter on oven dry basis, starch content (Dubios *et al.*, 1956), oxalate content, protein content (Mahadevan and Sridhar, 1986) alongwith organoleptic taste for cooking quality on 10 point scale.

Among the growth parameters (Table 2a), wide range of variation were shown by accessions.

Table 1. Passport data for *Colocasia esculenta* var. *esculenta* germplasm collections

Entry No.	Local/ Common Name	Source/Place of procurement		
		Village/Block	District	State/UT
E.Ac.-1	Sarukanda	Hoher	Ranchi	Bihar
E.Ac.-2	Manasaru	Aiginia	Bhubaneswar	Orissa
E.Ac.-3	Bhanda	Aiginia	Bhubaneswar	Orissa
E.Ac.-4	CV-9	Barapani	Bhubaneswar	Meghalaya
E.Ac.-5	CV-11	Barapani	Bhubaneswar	Meghalaya
E.Ac.-6	-	Barapani	Bhubaneswar	Meghalaya
E.Ac.-7	Noya Bunglow	Jorhat	Bhubaneswar	Assam
E.Ac.-8	Kanda	Jorhat	Bhubaneswar	Assam
E.Ac.-9	C-3	Jorhat	Bhubaneswar	Assam
E.Ac.-10	Assam long	Jorhat	Bhubaneswar	Assam
E.Ac.-11	Borkatchu	Jorhat	Bhubaneswar	Assam
E.Ac.-12	J.C.C-25	Jorhat	Bhubaneswar	Assam
E.Ac.-13	Kachalu	Katra	Jammu	J&K
E.Ac.-14	Kachalu	Katra	Jammu	J&K
E.Ac.-15	Ratalu	Kumharwand	Jagdalpur	Madhya Pradesh
E.Ac.-16	Ratalu	Kumharwand	Jagdalpur	Madhya Pradesh
E.Ac.-17	Kanda	Pali	Patna	Bihar
E.Ac.-18	Sarukanda	Gola	Hazarbiagh	Bihar
E.Ac.-19	Sarukanda	-	Ganjam	Orissa
E.Ac.-20	Hathpanja	Kanke	Ranchi	Bihar
E.Ac.-21	C-71	Barapani	Ranchi	Meghalaya
E.Ac.-22	TVM-293	Barapani	Ranchi	Meghalaya
E.Ac.-23	ML-3	Barapani	Ranchi	Meghalaya
E.Ac.-24	ML-8	Barapani	Ranchi	Meghalaya
E.Ac.-25	Kanda	Mathwalia	Bhojpur	Bihar
E.Ac.-26	Kanda	Sukurhuttu	Ranchi	Bihar
E.Ac.-27	Banda-1	Kumarganj	Faizabad	Uttar Pradesh
E.Ac.-28	Banda-2	Kumarganj	Faizabad	Uttar Pradesh
E.Ac.-29	Banda-3	Kumarganj	Faizabad	Uttar Pradesh
E.Ac.30	Banda-4	Kumarganj	Faizabad	Uttar Pradesh

E.Ac.-15 recorded the tallest plants of 147.00 cm height followed by E.Ac.-2 (136.00 cm) and E.Ac.-22 (129.33 cm), respectively while the shortest plants were observed in E.Ac.11 (61.00

cm). Very less variations were observed in case of number of leaves (4.73 to 7.73) but the number of tillers per plant varied in an drastically in most of the accessions in the range of 0.86

Table 2a. Pooled performance (1994-1996) of 30 accessions of *Colocasia esculenta* var. *esculenta* for growth characters

Entries	Plant height (cm)	No. of leaves/plant	No. of tillers/plant	Petiole length (cm)	Sheath length (cm)	Petiole/sheath length ratio	Leaf length (cm)	Leaf breadth (cm)	Leaf length/breadth ratio
E.Ac.-1	69.50	6.16	3.03	56.47	29.00	1.94:1	45.13	29.67	1.52:1
E.Ac.-2	136.00	7.13	6.13	129.33	58.33	2.21:1	51.33	39.13	1.31:1
E.Ac.-3	108.07	6.67	2.73	93.13	48.67	1.91:1	71.33	36.13	1.85:1
E.Ac.-4	107.67	4.77	3.67	81.40	45.67	1.78:1	60.33	45.60	1.32:1
E.Ac.-5	85.33	5.20	1.47	73.07	32.67	2.23:1	44.93	29.73	1.51:1
E.Ac.-6	76.67	6.33	2.47	68.07	33.00	2.06:1	45.67	33.93	1.35:1
E.Ac.-7	81.67	6.13	4.03	77.00	47.00	1.64:1	54.67	38.00	1.43:1
E.Ac.-8	90.33	7.40	1.80	83.07	36.00	2.31:1	48.00	30.93	1.55:1
E.Ac.-9	77.67	4.73	1.80	63.33	29.00	2.18:1	49.67	32.07	1.55:1
E.Ac.-10	82.33	5.67	2.20	71.73	35.67	2.01:1	46.33	29.73	1.56:1
E.Ac.-11	61.00	5.10	2.50	55.33	29.67	1.86:1	44.73	28.73	1.56:1
E.Ac.-12	102.33	6.20	2.40	51.20	28.67	1.79:1	43.33	29.33	1.46:1
E.Ac.-13	62.67	5.73	3.20	91.33	40.67	2.25:1	46.60	29.67	1.57:1
E.Ac.-14	113.00	5.03	1.73	98.93	45.33	2.18:1	50.67	34.93	1.45:1
E.Ac.-15	147.00	5.03	3.03	70.27	37.00	1.90:1	37.53	29.47	1.27:1
E.Ac.-16	66.00	4.93	0.86	53.80	29.00	1.86:1	50.07	29.40	1.70:1
E.Ac.-17	83.67	5.27	3.10	72.40	27.00	2.68:1	43.40	28.60	1.52:1
E.Ac.-18	78.67	5.33	2.23	69.27	31.67	2.19:1	43.00	24.87	1.73:1
E.Ac.-19	70.67	7.73	1.33	62.73	28.67	2.19:1	43.33	29.13	1.49:1
E.Ac.-20	70.67	6.10	5.73	59.00	26.00	2.27:1	47.07	34.13	1.38:1
E.Ac.-21	90.67	6.33	2.70	80.00	41.00	1.95:1	44.07	33.80	1.30:1
E.Ac.-22	129.33	6.40	1.57	103.87	47.67	2.18:1	55.00	39.47	1.38:1
E.Ac.-23	96.67	5.00	1.30	82.87	43.67	1.90:1	38.13	29.33	1.30:1
E.Ac.-24	81.67	6.10	2.13	68.67	27.67	2.48:1	46.87	30.40	1.54:1
E.Ac.-25	90.33	7.37	3.60	87.27	33.33	2.62:1	45.60	32.40	1.41:1
E.Ac.-26	85.33	4.77	2.60	71.60	39.00	1.84:1	64.27	45.53	1.41:1
E.Ac.-27	90.67	5.46	1.73	54.20	28.67	1.89:1	59.07	41.20	1.43:1
E.Ac.-28	80.26	5.83	1.07	68.87	34.33	2.01:1	42.93	25.40	1.69:1
E.Ac.-29	71.60	5.97	1.53	63.33	26.00	2.44:1	31.93	25.47	1.25:1
E.Ac.-30	100.80	6.67	1.73	88.67	29.67	2.99:1	42.06	31.47	1.34:1
Mean	89.61	5.88	2.51	75.01	35.66	-	47.90	32.59	-
Range	61.00-147.00	4.73-7.73	0.86-6.13	51.20-129.33	26.00-58.33	1.78:1-2.99:1	31.93-71.33	24.87-46.60	1.25:1-1.85
CD (0.05)	27.08	1.21	0.98	23.16	14.16	-	6.69	5.42	

Table 2b. Pooled performance (I 9S4-1996) of 30 accessions of *Colocasia esculenta* var. *esculenta* for tuber yield and its attributes

Entries No.	Corn length (cm)	Corn width (cm)	Corn weight (g)	No. of cormels/plant	Wt. of cormel/plant (g)	Tuber yield/plant (g)	Tuber yield/plot (kg)	Tuber yield (t/ha)
E.Ac.-1	17.93	7.27	720.00	12.47	669.66	1389.66	21.30	23.66
E.Ac.-2	19.40	5.67	550.00	5.33	399.33	949.33	16.73	18.59
E.Ac.-3	17.40	6.07	710.00	8.00	125.00	835.00	14.20	16.15
E.Ac.-4	17.73	10.07	432.00	9.00	95.00	527.00	8.03	8.92
E.Ac.-5	15.73	5.43	606.67	9.67	156.66	663.33	10.78	11.98
E.Ac.-6	15.33	10.73	670.00	6.80	130.00	800.00	15.30	17.00
E.Ac.-7	14.87	5.20	393.33	11.33	486.66	879.99	15.17	14.17
E.Ac.-8	17.07	5.40	343.33	8.73	156.66	499.99	7.27	8.08
E.Ac.-9	16.40	5.27	350.00	7.00	126.66	476.66	7.63	8.48
E.Ac.- 10	11.90	6.20	270.00	7.00	313.33	583.33	9.21	10.23
E.Ac.- 11	6.47	5.33	186.67	12.80	316.66	503.33	7.05	7.84
E.Ac.- 12	11.33	6.13	360.00	13.47	291.66	651.66	14.00	15.56
E.Ac.-13	15.17	6.27	486.67	7.60	180.00	666.67	10.40	11.56
E.Ac.- 1 4	11.60	5.77	300.00	8.07	162.66	462.66	7.84	8.71
E.Ac.-15	16.73	6.47	352.67	5.47	173.33	526.00	8.82	9.80
E.Ac.-16	14.73	5.47	239.33	6.93	261.66	500.99	8.48	9.42
E.Ac.- 17	17.77	4.87	306.67	5.07	200.00	506.67	8.48	9.42
E.Ac.- 18	19.33	6.40	150.00	0.40	70.00	220.00	3.71	4.12
E.Ac.- 19	20.80	7.13	566.67	7.53	136.66	703.33	11.60	12.89
E.Ac.-20	30.00	7.27	721.33	1.61	286.33	1006.66	19.77	21.97
E.Ac.-21	15.33	5.73	376.67	9.67	266.66	643.33	9.15	10.17
E.Ac.-22	10.73	10.83	660.00	2.06	73.53	735.53	10.15	11.28
E.Ac.-23	17.13	6.80	266.66	5.13	196.66	463.32	7.25	8.06
E.Ac.-24	14.47	5.20	433.33	8.20	150.00	583.33	8.85	9.83
E.Ac.-25	13.00	7.80	570.00	7.60	373.33	943.33	15.55	17.28
E.Ac.-26	17.87	7.27	725.00	9.53	433.33	1158.33	19.12	21.25
E.Ac.-27	15.33	6.87	430.00	8.40	209.33	639.33	10.90	12.11
E.Ac.-28	14.33	5.93	590.00	6.40	118.33	708.33	11.85	13.17
E.Ac.-29	15.53	4.73	385.00	3.40	236.66	621.66	10.60	11.78
E.Ac.-30	16.33	7.00	636.67	5.73	225.00	861.67	13.20	14.67
Mean	16.59	6.65	456.29	7.33	233.99	690.28	11.413	12.61
Range	6.47	4.73	150.00-	0.40-	70.00-	220.00-	3.71-	4.12-
	30.00	10.83	725.00	12.47	669.66	1389.66	21.300	23.66
CD (0.05)	3.56	2.11	145.34	5.02	162.82	284.91	4.41	5.11

in E.Ac.-16 to 6.13 in E.Ac.-2. The petiole length measurement ranged from 51.20 cm in E.Ac.-12 to 129.33 cm in E.Ac.-2. Maximum sheath length was recorded in E.Ac.-2 (58.33 cm) and minimum as 26.00 cm in case of two accessions viz. E.Ac.-20 and E.Ac.-29. Seven accessions viz. E.Ac.-2, E.Ac.-12, E.Ac.-21, E.Ac.-22, E.Ac.-23, E.Ac.-25 and E.Ac.-30 were observed to have plant height and petiole length more than 100cm. Sheath length measured was found independent of the petiole length which showed existence of genetic differences among the accessions. Leaf length was recorded maximum in E.Ac.-3 (71.33cm) followed by E.Ac.-26 (64.27cm) and E.Ac.-4 (60.33cm) respectively. The range of leaf breadth varied from 24.87cm in E.Ac.-18 to 45.60 cm in E.Ac.-4. The ratio of petiole length and sheath length ranged from 1.78:1 (E.Ac.-4) to 2.99:1 (E.Ac.-30) while that of leaf length/breadth ratio found to vary from 1.25:1 (E.Ac.-29) to 1.85:1 (E.Ac.-3).

Wide range of variation were found yield attributing characters and tuber yield (Table 2b). The length of corm varied from 6.47 cm in E.Ac.-11 to 30.00 cm in E.Ac.-20 which was followed by E.Ac.-19 (20.80cm) and E.Ac.-2 (19.40 cm) respectively. E.Ac.-22 recorded the maximum corm width (10.83cm) while other accessions like E.Ac.-6 (10.73cm) and E.Ac.-4 (10.07 cm) ranked second and third in order. Corm with minimum width was observed in E.Ac.-29 (4.73 cm). Weight of the main corm varied from 150.00g in E.Ac.-18 to 725.00g in E.Ac.-26. E.Ac.-26 recorded to have heaviest main corm of 725.00g which closely followed by the entries E.Ac.-20 and E.Ac.-1 having corm weight of 721.33 g and 720.00g respectively. Number of cormels per plant varied from 0.04 in E.Ac.-18 to 13.47 in Ac.-12 which is in agreement with the reports of existence of less number of cormels in Dasheen type (Plucknett, 1983). Weight of cormels per plant ranged from 70.00g (E.Ac.-18) to 669.66g (E.Ac.-1). Tuber yield per plant was

recorded maximum in E.Ac.-1 (1389.66g) followed by the accessions E.Ac.-20 (1006.66g) and E.Ac.-26 (1158.33g). The minimum tuber yield per plant was recorded in E.Ac.-18 (220.00g). The estimated tuber yield was maximum in E.Ac.-1 (23.66 t/ha) which was closely followed by the accessions E.Ac.-20 (21.97 t/ha) and E.Ac.-26 (21.25 t/ha) respectively.

Among quality characteristics dry matter percentage determined by oven dry basis was maximum as 25.46 per cent in E.Ac.-17 which was closely followed by E.Ac.-22 (25.42%) and E.Ac.-4 (25.38%) respectively. Drymatter production percentage was recorded minimum in E.Ac.-19 (22.14%). Colocasia in general is also good source of digestible starch (Onwume, 1978). Starch content was estimated to be high in accessions viz. E.Ac.-17 (19.60%), E.Ac.-2 (19.40%), E.Ac.-3 (19.40%) etc. while the minimum value was observed in E.Ac.-20 (13.20%). The factor that limits the intake of colocasia tuber as food is the acidity caused by the presence of oxalate content which in this case varied from 0.34 per cent (E.Ac.-14) to 0.69 per cent (E.Ac.-8). Cooking quality adjudged by organoleptic taste having 10 point scale revealed that accessions E.Ac.-23 (9.0), E.Ac.-29 (9.0), E.Ac.-22 (8.8), E.Ac.-13 (8.6), E.Ac.-20 (8.6), E.Ac.-28 (8.6), E.Ac.-1 (8.4) and E.Ac.-12 (8.4) showed their superiority.

Oxalate content value (Table 2c) when compared with tuber yield of corresponding accession, showed that accessions which were having low oxalate content were mostly low yielders but among the high yielding accessions viz. E.Ac.-1, E.Ac.-20, E.Ac.-26 with oxalate content 0.62, 0.48, 0.48 per cent are easily digestible with good taste after cooking. So these high yielding accessions could be selected for further breeding improvement programme of this crop.

Table 2c. Pooled performance (1994-1996) of 30 accessions of *Colocasia esculenta* var. *esculenta* for quality characters

Entries No.	Drymatter (%)	Starch (%)	Oxalate (%)	Protein (%)	Organoleptic taste score(0-10)
E.Ac.-1	24.24	18.5	0.62	2.62	8.4
E.Ac.-2	25.18	19.4	0.49	1.26	5.6
E.Ac.-3	22.78	19.4	0.52	1.96	6.8
E.Ac.-4	25.38	19.0	0.41	0.98	8.2
E.Ac.-6	23.44	16.7	0.58	1.72	7.6
E.Ac.-6	23.66	16.8	0.42	0.72	4.4
E.Ac.-7	25.46	16.0	0.56	2.86	7.4
E.Ac.-8	24.66	16.4	0.69	2.54	6.2
E.Ac.-9	23.72	16.8	0.61	2.14	4.6
E.Ac.-10	24.46	14.2	0.62	2.12	2.8
E.Ac.-11	25.26	18.6	0.62	1.78	3.6
E.Ac.-12	23.88	15.4	0.46	1.08	8.4
E.Ac.-13	22.46	14.4	0.48	1.12	8.6
E.Ac.-14	22.84	15.2	0.34	1.28	8.2
E.Ac.-15	25.18	19.4	0.53	0.96	9.0
E.Ac.-16	24.82	19.2	0.38	0.92	8.4
E.Ac.-17	25.46	19.6	0.51	1.12	7.8
E.Ac.-18	23.83	18.5	0.63	2.16	4.8
E.Ac.-19	22.14	14.4	0.46	0.98	3.8
E.Ac.-20	22.82	13.2	0.48	1.76	8.6
E.Ac.-21	22.56	13.6	0.42	0.88	6.4
E.Ac.-22	25.42	15.4	0.56	1.06	8.8
E.Ac.-23	23.28	14.8	0.68	1.92	9.0
E.Ac.-24	25.32	18.6	0.62	1.18	6.4
E.Ac.-25	24.32	17.4	0.63	1.82	6.8
E.Ac.-26	23.18	18.2	0.48	1.06	4.8
E.Ac.-27	23.22	16.4	0.49	0.86	6.6
E.Ac.-28	22.36	16.4	0.39	1.08	8.6
E.Ac.-29	24.46	17.6	0.52	1.24	9.0
E.Ac.-30	23.62	15.2	0.61	1.74	6.8
Mean	23.99	16.82	0.53	1.51	—

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VARIATION IN THE MINERAL COMPOSITION OF SOME GENOTYPES OF POMEGRANATE (*Punica granatum* L)

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Pomegranate genotypes viz., wild, Kandahar and Jalore Seedless were subjected to chemical analysis. Sodium, calcium, iron, zinc, aluminium, copper and manganese contents were significant in wild pomegranate. Out of 3 genotypes, Jalore Seedless showed the highest content of magnesium (7.63 ppm) in comparison to wild (3.63 ppm) and Kandahar (3.55 ppm).

Key words : Minerals, pomegranate, cultivated, wild

Pomegranate, popularly known as anar or dalim or dadima, came to India from the Middle East via Persia or Afghanistan presumably in the first century, and acclimatized very well in the tropical and subtropical regions. In J & K state, it is found abundantly in the subtropical forests of Jammu and Kashmir state in the wild form which is used in the preparing anardana and finds use in the culinary and medical preparations (Mahajan *et al.*, 1992). The pomegranate fruit is a rich source of minerals and known to contain both major and minor nutrients. Various macro- and micro-nutrients which display a vital role in fruit metabolism, are also the inseparable part of the human diet (Sharma, 1995). Adequate amount of these nutrients in human bodies control a variety of functions like calcium in structural integrity, sodium in maintaining water balance inside and outside of body cells, iron in the formation of red blood cells, zinc in the sexual maturation and reproduction, copper in iron absorption and manganese in defence mechanism (Considine, 1982; Dewan, 1991; Ruheey *et al.*, 1993).

No comparative study relating to the mineral status of cultivated and wild genotypes has been conducted so far in Jammu and Kashmir, therefore, the present investigation was made to study the mineral composition of wild pomegranate in comparison to the cultivated genotypes of pomegranate.

The fruits of different genotypes (wild, Kandahar and Jalore Seedless) collected from the different sources were brought to the laboratory and their chemical analysis was done at SKUAST, RHRS, Udhaywalla and the Department of Chemistry, Jammu University, Jammu. The juice from pomegranate fruits was obtained by pressing seeds through muslin cloth and was subjected to analysis of minerals using Perkin Elmer Model 3100 (AAS) Atomic Absorption Spectrophotometer.

Various nutrients as influenced by various genotypes of pomegranate are given in the Table 1. The contents of sodium, calcium, iron, zinc, aluminium, copper and manganese were significantly affected by the genotypes and their

Table 1. Fruit mineral composition (ppm) of pomegranate genotypes

Genotype	Sodium	Calcium	Magnesium	Iron	Zinc	Aluminium	Copper	Cadmium	Manganese	Tellurium
Wild	6.48	47.62	3.63	7.15	4.19	2.20	1.23	0.02	0.26	0.31
Khandhar	5.89	11.42	3.55	0.91	1.47	0.60	0.43	0.01	0.18	0.44
Jalore Seedless	5.05	15.36	7.63	2.06	2.46	0.64	0.41	0.01	0.16	0.38
CD (0.05)	0.16	4.43	0.21	0.23	0.26	0.11	0.09	NS	0.06	NS

highest values were registered with the wild pomegranate as 6.48, 47.62, 7.15, 4.19, 2.20, 1.23 and 0.26 ppm, respectively. Of the 3 genotypes, Jalore Seedless showed the highest contents of magnesium (7.63 ppm) in comparison to wild (3.63 ppm) and Kandahar (3.55 ppm) pomegranates. Cadmium and tellurium which are toxic to human body were found less than permissible toxic limit and did not show any significant differences among the 3 genotypes, tested during the course of investigations.

In the present studies, the level of nutrients in the cultivars were close to the ranges as reported by Considine (1982), however, the status of most of the nutrients was 3-4 times higher in case of wild pomegranate to cultivated forms. The variation in the genetic make up of individual genotype, soil and environment conditions may be the possible causes for contributing the

differences in mineral composition among the genetic resources as also observed.

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GENETIC RESOURCES OF TEMPERATE FRUIT PLANTS IN HIMACHAL PRADESH

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A National Hortorium at Kothai (Shimla, India) maintains a large germplasm collection of 579 varieties/species comprising pome fruits (215 apple, 56 pear, 32 *Malus* species), stone fruits (37 cherry, 65 plum, 37 apricot, 5 persimmon) and nut crops (31 almond and 1 each of chestnut and walnut) were introduced. Cultivars namely Topred, Red Spur, Vance Delicious, Summer Queen of apple, Red Bartlett, Starkrimson of pear, Non Pareil, Ne Plus Ultra, Drake of Almond; Triumph Domini, Pieterose Nigre, Germersdorfer of cherry and Partap of Walnut have been found promising and released for cultivation in Himachal Pradesh.

Key words : Temperate fruits, germplasm, cultivar, maintenance, conservation

A National Hortorium for introduction, collection and preserving of all cultivated varieties of temperate horticultural plants and their wild relatives was established at Kotkhai by Indian Council of Agricultural Research in 1961. This hortorium was lately transferred to Dr Y.S. Parmar University of Horticulture and Forestry and renamed as Temperate Horticultural Research Station at Kotkhai, Shimla (Himachal Pradesh). During the initial drive, a large germplasm collection of 470 varieties of different temperate fruits were collected and established and have been evaluated from time to time.

The germplasm collection consisted of 470 varieties comprising pome fruits (215 apple, 56 pear, 32 *Malus* species), stone fruits (37 cherry, 65 plum, 37 apricot, 5 persimmon) and nut crops (31 almond and 1 each of chestnut and walnut). Later 70 more cultivars of different temperate fruits were added. These germplasm have been evaluated for their growth, cropping, fruit quality

and a large number of these have been released in the state. The available genetic resources are listed in Table 1.

Under the apple germplasm evaluation programme, a number of varieties namely Starking Delicious, Rich-a-red, Topred, Vance Delicious, Golden Delicious, Summer Queen and Red Spur have been recommended for fruit grower of Himachal Pradesh (YSPUH&F, 1996).

In case of pear, three cultivars namely Red Bartlett Max Red Bartlett and Starkrimson have been found promising. Almond cultivars viz., Non Pareil, Drake, Kashmir Seedling and I.X.L. were recorded vigorous under high hill temperate wet zone, and were found suitable for green almond market. These varieties were also less affected by gummosis. In cherry germplasm, screening programme Triumph Domini was found most promising early maturing cultivar followed by Pieterose Nigre and Germersdorfer. Some varieties like Triumph Domini, Bigarreau Noir Hative,

Germersdorfer and Emperor Francis were also found comparatively tolerant to shot hole disease (Gautam *et al.*, 1993, 1995, 1997).

Large number of germplasm has also been recommended in peach, plum and apricot. Recently Partap walnut has been released from the station.

Germplasm maintained at Temperate Horticultural Research Station, Kotkhai (Shimla)

Apple

a) Colour strains

Bright-N-Early	Galla
Hardeman	Mollies Delicious
Lalla Delicious	Royal Red
Richared	Top Red
Vance Delicious	

b) Super types

Golden Spur	Hardeipur
Oregonspur	Miller stureddee spur
Red Chief	Red Spur
Silver Spur	Spur type Red
Sky Spur	Starkrimson
Starkspur Golden	Well Spur

c) Pollinisers varieties

Grainy Smith	Glauster
Golden Delicious	Mc. Intosh
Red Gold	Spartan
Summer Queen	Tydemans Early
Worcester	Lord Lambourne

d) Crab pollinisers

Crimson Golden	Golden Hornett
Manchurian	Malus Floribunda
Snowdrift	Redflush

e) Scab resistant

Co-op-13	Karyjan
Freedom	Liberty
Mcpree	Novamac
Nova Easygro	Sir prize

f) Other varieties

Akane	Anna
Boskoop	Boycon
Chailmoft	Chaubattia Ambrosia
Early Victory	Edward

Ellison's Orange	Fall Pippin
High Early	Ingrid Marie
Indo	Jonared
King David	King Lucious
King Pippin	Providence
Laxton's Fortune	Lord Lambourne
Miller's Seedling	Norfolk Beefing
Parlin's Beauty	Pearson's Late
Pippin Litovski	Pumbis
Porto	Red Baron
Red June King Pippin	Rose Marie
Royal Galla	Schlomit
Sharp's Yellow	Sign Tillish
Stema Red	Summer Red
Survivets	Surkh Trel
Summer Champion	Stark Earliest
Tropical Beauty	Pear Varieties
Autumn of Yakolov	Awal Number
Bagugosha	Beurre Giffard
Bartlett	Basuiodsc Favourite
Beurre Bosc	Beurre d' Amanlis
Beurre Diel	Beurre Hardy
Beurre Capiaumont	China Pear
Pear Varieties	Common Pear
Conference	Country Pear
Decanna de Kulli	Devoe
Doyenne du Comice	Duchess de Bordeaux
Durandeau	Flemish Beauty
Durandeau	Flemish Beauty
Durandeau	Glou Morceau
Gross Calabore	Ishiiwase
Jargonelle	Kashmir Pear
Kiskusui	Laxton's Superb
Leconte	Lisnova Karasvitsa
Luchimitsa Kalapa	Manning Elizabeth
Marie Louise Marriflat	Max Red Bartlett
Monarch	Monteca hardy
Monteca Labrum	Napolean
New Pear	Niji seikii
Nouveau Poiteau	Okusankichi
Passe Crassane	Princess
Red Bartlett	Seckel
Shinseiki	Smart Pear
Starkrimson	Starking Delicious
Stark Winter Bartlett	Thumb Pear
Victoria	Weldon

William Basuioceae hybrid	William Bon
Chretien	Yakumo
Cherry Varieties	Bigarreau Noir Hative
Bigarreau Noir Gross	Bigarreau Severne
Bedford Prolific 202	Bellia Italia
Black Heart	Bombe-de-Contnari
Durone Nero I	Durone dell Anelta
Early River	Emperor Francis
Early Purple	Ferroia
Gaucer	Gennelce
Germersdorfer	Guigne Noir Gross
Lapins	Mora di Cazzano
Merchant	Napolean
Pinkish Early	Pietroase Nigre
Red Heart	Sandara Tardiva
Schmidt	Seneca
Suda Hardy	Stella
Triumph Domini	Van
Yama Jakura	White Heart Biglate
Plum Varieties	Black Chamba
Burbank	Burbank Elephant Heart
Burbank Great Yellow	Burbank Mammoth
Cambridge Gage	Damson
Daniston's Superb	Early Transparent Gage
EC 330935	EC 330936
EC 330937	EC 330938
EC 331111	Formosa
Frontier	Green gage
Mariposa	Methley
Prune	Raisin
Red Ace	Red Beauty
Santa Rosa	Satsuma
Sweet Early	Tarool
Transparent Gage	Victoria
Wickson	
Apricot	
Charmagz	Hulman
Suffeda	Shakarpara
St. Ambroise	Sayeb
Toyrinthos	New Castle
Rival	

Walnut

Colby	EC 36748
EC 36749	Govind
Kilba Selection	Hansen
Kotkhai Selection No. I	Kotkhai Selection No. II
Lake English	Payne
Partap	Tutle-16
Tutle-31	

Almond

Afghanistan Seedling	Briggs Hardshell
Drake	Dhebar
EC 42149	Kashmir Seedling
Merced	Non Pareil
Ne Plus Ultra	Riba Selection
Satwant Raj	Spillo-16
Spillo-18	

Peach

Early White Giant	Fayette
Flame Kist	July Elberta
Spring Crest	Shimizu Hakuto
Somerset	Snow Queen (Nectarine)
World's Earliest	

Persimmon

Astrigent	Gosho
Hyakume	Raw Eating
Hachiya	

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EVALUATION OF FEMALE CLONES OF POINTED GOURD

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Sixty four female clones of pointed gourd (*Trichosanthes dioica* Roxb.) collected from parts of Bihar and West Bengal showed wide range of variation in vine length, leaf length/breadth, fruit length, fruit girth, fruit weight, pericarp thickness, number of fruits/plant and fruit yield per plant. Some promising clones included IC66-1, IC63-1, IC50-4, IC64-2, IC97-2 and IC34-4.

Key words : Pointed gourd, *Trichosanthes dioica*, dioecious, female clone, evaluation

The pointed gourd, *Trichosanthes dioica* Roxb., locally called 'parwal' or 'patal' is an important cucurbitaceous vegetable crop extensively cultivated in India particularly in West Bengal, Bihar, eastern Uttar Pradesh, Assam and Tripura. It is dioecious and vegetatively propagated perennial cucurbit. The female clones, though highly heterozygous in nature are perpetuated uniformly through clonal propagation. However, sexual reproduction results segregation and recombination producing new gene combination. The seedlings, differing from the parent in genotype and phenotype is established as distinct clone and remain in the cultivar population as a mixture. Thereby, great deal of variation in the clones is created. However, wide variation in pointed gourd is being continuously eroded mainly because of over-dependence of very few indigenous cultivars for commercial cultivation.

Sixty eight female clones of pointed gourd were assembled through extensive collections from major pointed gourd areas of West Bengal and some parts of Bihar. These clones were grown in Horticultural Research Station, Bidhan Chandra Krishi Viswavidyalaya, Mondouri in 1996-97 for

grouping based on fruit shape and size. The clonal population fell under four broad groups namely, small fruited (less fruit length and girth) group, spindle shaped fruit, oval fruit and nearly cylindrical fruit. Fruit shape of the small group was mostly oval but spindle and tapering shapes were also there. Fruits of all the clones belong to four basic colour : dark green with white stripes, dark green with faint pale green stripes, pale green with inconspicuous stripes and palegreen with lines in place of stripes.

These 68 female clones (belonging to 4 groups) were evaluated separately for growth and fruit characters and yield in randomised block designs with three replications in 1997-98 (Oct.-August) at Mondouri under new alluvial agroclimatic zone. The soil type is loamy in nature. The clones were grown from vine cuttings using ring method of planting. Each replication consisted of five plants in 3 × 3m beds. Male plants were kept at the rate of 10 per cent in the population for ensuring successful fruit set. Three random plants in each replication of the clones were tagged and data were recorded. Five fully grown leaves per selected plant were sampled

Table 1. Diversity for growth and fruit characters in pointed gourd clones

Character	No. of clones	Frequency (%)
1. Vine length (cm)		
Short (< 100)	12	17.6
Medium (< 200)	40	58.8
Long (< 300)	11	16.2
Very long (> 300)	5	7.3
2. Node number to first flower		
Early (< 10)	25	36.7
Medium (< 15)	29	42.6
Late (> 15)	14	20.5
3. Fruit shape		
Spindle ¹	26	38.2
Oval ²	20	29.4
Tapering towards end ³	4	5.8
Nearly cylindrical	18	26.4
4. Fruit length (cm)		
Small (< 6)	21	30.8
Medium (< 8)	44	64.7
Long (> 8)	3	4.4
5. Fruit weight (g)		
Light (< 15)	7	10.2
Medium (< 30)	50	73.5
Heavy (> 30)	11	16.1
6. Pericarp thickness (cm)		
Thin (< 0.3)	39	57.3
Medium (< 0.5)	22	32.3
Thick (> 0.5)	7	10.2
7. Fruit yield/plant (g)		
Low (< 450)	23	33.8
Medium (< 650)	21	30.8
High (< 850)	12	17.6
Very high (> 850)	12	17.6

1. Small sized fruit (less length and girth) in 4 clones,

2. Small sized fruit in 7 clones

3. Small sized fruit in all the clones

to record leaf characters. Five tagged fruits of 12 days old from each selected plant per replication were employed to record fruit characters. Fruit yield was the cumulation of all the periodical harvests at marketable maturity.

The clones showed wide range of variations for all the characters revealing under scope for clonal selection. The range of variations considering all the 68 clones irrespective of the groups for the characters observed in vine length (83.3-536.9 cm), node number to bear the first flower (5.5-24.3), leaves per plant (13.6-69.3), leaf length (4.7-8.5 cm), leaf breadth (5.0-8.4 cm), fruit length (3.3-9.3 cm), fruit girth (6.1-11.6 cm), fruit volume (14.0-59.8 c.c), fruit weight (14.2-45.9 g), pericarp thickness (0.27-0.94 cm), seed number per fruit (4.9-17.7), fruits per plant (9.6-50.2) and fruit yield per plant (201.2-1395.3 g). Frequency distribution of the clonal collections in relation to some characters are presented in Table 1. Vine length of most of the clones was medium (1-2 m). A good percentage of clones (36.7) showed early flowering habit. Prevalent fruit shape was spindle. Most of the clones bore fruits of medium length (6-8 cm) at perfect picking stage (12 days after anthesis). Long fruits were borne on very few clones. There revealed preponderance of medium weight (15-30 g) fruits. Thick pericarp which is an excellent quality trait was shown by seven clones. Low and medium yielding clones together accounted for 64 per cent. Very high yielding clones identified were IC-66-1, 1C-63-1, 1C-40-5, 1C-61-5, 1C-16-1, 1C-37-4, 1C-50-4, 1C-50-2, 1C-20-1, 1C-64-2, 1C-97-2 and 1C-34-4.

EFFECT OF SHELL ON CONSERVATION OF SEED-VIABILITY IN GROUNDNUT, *Arachis hypogaea* L

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There are genotypic differences among groundnut accessions for maintenance of longevity of seed-viability in storage in relation to the shell of pods. Only six accessions showed that significant difference in longevity of seed, hence, groundnut accessions can be conserved equally safe as of seeds in seed genebank under medium-term conditions depending on genotype. However, more accessions need study to confirm these observations.

Key words : *Arachis hypogaea*, conservation, seed viability

Groundnut seeds are typically orthodox and withstand desiccation to low moisture content. Seed storage therefore, is the most convenient method of conservation. However, the high oil content (31.8 to 41.0%) of seeds, makes it a poor storer. The viability of seeds during long-term storage in seed banks has not been investigated and the seed storage conditions, which maximise seed-longevity, still remain unresolved. Bass (1968) reported that hand-shelled groundnut seeds can be stored for 5 years or longer without loss of viability at 10°C and 50 per cent RH. Norden (1981) observed appreciable loss in germination of shelled seeds, stored for 10 years with less than 6 per cent moisture content in sealed containers at low temperatures (2° to 5°C). Baskin (1979) indicated that seed-viability is maintained better when stored with shell, while Navarro *et al.* (1989) observed genotypic differences in longevity in relation to the shell. These studies, include only few genotypes, representing only a small spectrum of the total variability. Further, seeds were stored only for a short duration.

International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) holds the world collection of germplasm of groundnut, totaling about 15,000 accessions from 91 countries. Most of the germplasm is conserved as active collections in medium-term stores (4°C and 30% RH) in plastic containers as pods. Under these conditions, the seed-viability has been maintained fairly well over times. However, pods require greater space, and the quality of seeds remain concealed, having implications on large-scale conservation. In the present investigation, the seed longevity of shelled and unshelled groundnut was studied.

Nineteen accessions of groundnut, representing four of six known botanical varieties were used in the study (Table 1). They were planted in the post-rainy (PR) season of 1990-91 under controlled conditions. Regular plant protection measures were taken to minimise biotic stresses and enable production of healthy seeds. The pods were harvested at maturity. Fifty per cent of pods were hand shelled while the remaining were kept unshelled. Both pods and seeds were

dried to 10 per cent seed moisture level and stored separately in cloth bags in a single plastic container at 4°C and 30 per cent RH. After 5 years of seed storage, the viability of both shelled and unshelled seeds was tested. Two replicates of 50 seeds each were placed between two layers of moist paper towels (Non-toxic standard towels, Seed-buro) and incubated at 25°C. Germination counts were made 7 days after incubation. The seed of accessions of subspecies *hypogaea* were treated with 20 ppm of ethereal solution (2-4 Dichloroethyle-phosphonic acid) to break dormancy. The data were analysed statistically using the Complete Randomised Block Design.

The germination at the start of seed storage ranged between 94 and 100 per cent (with a mean of 98.3%). After five years of storage, the viability of unshelled seeds varied between 70 and 98% (with a mean of 86.7%), while that of shelled seeds was between 56 and 98 per cent (with a mean of 85.9%) (Table 2).

The mean viability is marginally low, when accessions are conserved as seeds. However, a critical analysis of the results reflects the effect of shell on longevity of seed-viability. In 12 of 19 genotypes studied, seed-viability was better maintained when stored as pods, which was in line with previous observations of Baskin (1979). The groundnut seed has a thin seed coat, the shell in majority of accessions may be providing a protective covering to seeds from attacks of pathogens and from mechanical injuries. In the remaining seven genotypes, however, seed-viability was higher even when stored as seed (Table 2). Of these seven genotypes, three belong to subspecies *fastigiata* var. *fastigiata*, three to subspecies *hypogaea* var. *hypogaea* type runner, and one to var *hypogaea* type bunch. Most of these genotypes have smaller seed size indicated by lower 100 seed weight, thin shell: indicated by

Table 1. Identities, biological and taxonomic status of accessions

ICRISAT identity	Botanical variety	Biological Status	Country of origin	100 seed weight (g) (Rainy)	Oil content (%)	Shelling (%)
ICG 3078	<i>vulgaris</i>	Landrace	Sudan	45.0	-	74
ICG 3244	<i>vulgaris</i>	Landrace	Tanzania	60.0	45.7	75
ICG 2978	<i>vulgaris</i>	Breeding line	U.S.A.	40.0	41.7	84
ICG 3034	<i>vulgaris</i>	Breeding line	India	32.0	-	77
ICG 10516	<i>fastigiata</i>	Landrace	Bolivia	37.0	-	77
ICG 10634	<i>fastigiata</i>	Landrace	Argentina	33.0	-	77
ICG 5988	<i>fastigiata</i>	Breeding line	U.S.A.	33.0	42.2	74
ICG 10217	<i>fastigiata</i>	Breedling line	Sudan	41.0	-	73
ICG 6646	<i>peruviana</i>	Landrace	Peru	45.0	45.6	67
ICG 10965	<i>peruviana</i>	Landrace	Peru	51.0	-	68
ICG 3841	<i>hypogaea</i> bunch	Landrace	India	40.0	42.1	70
ICG 3893	<i>hypogaea</i> bunch	Landrace	Tanzania	40.0	46.2	69
ICG 3019	<i>hypogaea</i> bunch	Breedling line	U.S.A.	76.0	44.6	69
ICG 3046	<i>hypogaea</i> bunch	Breeding line	India	49.0	45.0	73
ICG 4532	<i>hypogaea</i> bunch	Released cultivar	U.S.A.	40	39.9	72
ICG 2799	<i>hypogaea</i> runner	Landrace	U.S.A.	62.0	41.6	71
ICG 4129	<i>hypogaea</i> runner	Landrace	India	44.0	43.5	69
ICG 2829	<i>hypogaea</i> runner	Breeding line	India	48.0	43.0	67
ICG 4765	<i>hypogaea</i> runner	Breedling line	Taiwan	60.0	-	70

PR : refers to post-rainy season

Table 2. Germination percentage of shelled and unshelled seeds after five years from storage

Accession ID ¹	Germination percentage after five years from storage			
	At the start of seed storage	in pod	in seed	Difference
ICG 3244	95.0	88.0	80.0	8.0
ICG 3078	85.0	70.0	56.0	14.0
ICG 3034	88.0	86.0	72.0	14.0
ICG 2978	90.0	86.0	72.5	13.5
ICG 10516	100	78.0	96.0	-18.0*
ICG 10634	100	92.0	94.0	-2.0
ICG 5988	95.0	72.0	90.0	-18.0*
ICG 10217	100	96.0	84.0	12.0*
ICG 10956	90.0	82.0	72.0	10.0
ICG 6646	100	94.0	84.0	10.0
ICG 3841	100	94.0	86.0	8.0
ICG 3893	100	98.0	94.0	4.0
ICG 3019	100	94.0	84.0	10.0
ICG 3046	95	92.0	86.0	6.0
ICG 4532	100	94.0	98.0	-4.0
ICG 2799	100	80.0	95.0	-15.0*
ICG 4129	98.0	70.0	94.0	-24.0**
ICG 2829	98.0	94.0	90.0	4.0
ICG 4765	100	88.0	98.0	-10.4*

¹Accession ID = ICRISAT Groundnut (ICG) Accession number;

*Significant at 1%, **Significant at 5%

the high shelling percentage, and low oil content (Table 1). Thereby, suggesting that in these accessions of var. *fastigiata* (Valencia) and var. *hypogaea* type runner shell does not contribute significantly towards the maintenance of seed-viability and more than shell, some other characteristics, such as seed size, seed coat or chemical composition (less oil), probably confer significantly greater towards maintenance of seed-viability.

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Short Communication

SOMATIC EMBRYOGENESIS IN WALNUT (*Juglans regia* L.)

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In Walnut (*Juglans regia* L) cultivars viz., 'Netar Akhrot' and 'Govind', somatic embryos were produced on embryonic axis and cotyledonary tissue explants cultured on DKW medium supplemented with 2mg/l kinetin, 1mg/l BA and 0.01 mg/l IBA for 3 weeks. In the present investigation, apparently normal bipolar somatic embryos have been obtained. However, since the explant source is immature embryo, the culture represents varying genotypes. The difference could be seen from differential response of explants to culture condition. Attempts were made to regenerate plants from somatic embryos.

Key words : Walnut, DKW medium, somatic embryogenesis

In India, walnut is mostly grown as scattered trees and not in the form of well maintained orchards. Many areas of Jammu and Kashmir, Kangra (H.P.) and hills of Uttar Pradesh are famous for walnut production. The Jammu and Kashmir is the principal walnut growing state having monopoly in production of export quality nuts (Dar, 1987; Qureshi and Dalal, 1985). In Himachal Pradesh, the area under cultivation was 5459 hac, in 1994-95 (Anon., 1995). Almost all parts of the plant are utilized in one way or the other but the fruit and timber have been put to maximum use. The fruit has excellent flavour and is mainly consumed as a dry fruit. Walnut is rich in proteins, fats and minerals. However, the cultivation of this crop has remained neglected on account of non-availability of better genotypes and due to its long bearing habit. Conventional methods of vegetative propagation are relatively slow and often difficult. The use of micropropagation is possible (McGranahan *et al.*, 1987), however, many problems, like ageing and juvenility (Jay-Allemand *et al.*, 1987),

contaminants, rate and quality of rooting and soil transfer are still remain constraints for mass propagation. The possibility of inducing somatic embryogenesis for obtaining plants has been investigated (Tulecke and McGranahan, 1985; Tulecke *et al.*, 1988). In the present investigation, attempts have been made for somatic embryogenesis from immature embryos in *Juglans regia*.

Nuts from open pollinated crop of walnut cultivars, viz., 'Netar Akhrot' and 'Govind' were collected from the Orchards, Department of Fruit Breeding, University of Horticulture and Forestry, Solan (H.P.) at an interval of four weeks after full bloom. They were surface sterilized with 1-1.5% (v/v) sodium hypochlorite for 15-20 min and washed with sterile water 3-4 times and cracked under a laminar flow with the help of vice. The embryonic axes and cotyledonary explants were removed using aseptic procedure and inoculated into Driver and Kuniyuki walnut (DKW) medium (1984) supplemented with

different concentrations of 1-2 mg/l BA, 2 mg/l kinetin, 0.01-0.05 mg/l IBA, 250 mg/l glutamine and 500 mg/l kanamycin alone or in combination. The cultures were incubated in dark at $25 \pm 2^\circ\text{C}$ and were transferred to the basal medium after three weeks to induce somatic embryos. They were subsequently maintained on the same medium by repeated transfers at an interval of two weeks.

Table 1 shows the sampling time and the type of fruit used. There is a specific time between the anthesis and fruit maturity when somatic embryogenesis was possible. The nuts collected in June i.e., 12 weeks after pollination, were capable of forming somatic embryos. Tulecke and McGranahan (1985) reported optimum time for obtaining somatic embryos from the walnut 6-11 weeks after pollination. Long *et al.* (1995) reported that in Eastern black walnut nuts collected 16 weeks after anthesis formed adventitious shoots on cotyledonary explants on medium containing 2, 4-D. There was no callus initiation on cotyledonary tissue and embryonic axis on DKW medium supplemented with IBA or kinetin. However, on DKW medium with 2 mg/l kinetin, 1 mg/l BA and 0.01 mg/l IBA, the callus was induced which was nodular, friable creamish in colour (Plate 1a). A light brown, friable and nodular callus was formed when kanamycin (500

mg/l) was added to the medium (Plate 1b). There was no callusing on basal medium.

Table 1. Sampling time and type of fruit used (after full bloom)

Sampling time (month)	Type of fruit
April (4 weeks)	Wndocarp soft, non-lignified endosperm liquid and the cotyledons were not visible. Fruits can be cut easily with knife.
May (8 weeks)	Endocarp soft, slightly lignified, endosperm gelatinous and cotyledons beginning to fill the seed cavity. Fruits can cut with knife.
June (12 weeks)	Endocarp hard, lignified. Cotyledons completely fill the seed cavity with fully developed embryonic axis no visible endosperm. Fruits can be cracked under aseptic condition with vice.

In the present investigation, somatic embryos were produced on the embryonic axis and cotyledonary tissue explants cultured on DKW medium supplemented with 2 mg/l kinetin, 1 mg/l BA and 0.01 mg/l IBA for 3 weeks and transferred to the basal medium subsequently and incubated in dark (Plate 1c and d). Tulecke and McGranahan (1985) reported somatic embryogenesis from cotyledonary explants in walnut using $4.4 \mu\text{M}$ BA, $93 \mu\text{M}$ kinetin and $0.05 \mu\text{M}$ IBA. However, Neuman *et al.* (1993)

Table 2. Effect of growth regulators on somatic embryogenesis in walnut

DKW medium with growth regulators (mg/l)				Number of explants showing somatic embryogenesis in cultivars			
				Netar Khrot		Govind	
				Embryonic axis	Cotyledon	Embryonic axis	Cotyledon
Kinetin	BA	IBA	Kanamycin				
-	-	-	-	-	-	-	-
-	-	-	500	-	-	-	-
2	1	0.01	-	3.33 (27.75)	9.33 (31.10)	2.33 (19.41)	8.00 (26.66)
2	1	0.01	500	7.66 (63.83)	20.67 (68.90)	5.33 (44.46)	18.00 (66.00)
CD 0.05				0.769	0.768	0.768	0.941

did not obtain embryogenesis from *J. regia* following Tulecke's approach which shows differential response of the genotypes. Aly *et al.* (1992) could obtain somatic embryos by using DKW supplemented with 4.6 μ M zeatin, 0.45 μ M TDZ and 17 μ M IAA. Long *et al.* (1995) used Woody Plant Medium (WPM) to produce somatic embryos from immature cotyledon explants of Eastern black walnut. It is noticed that only 26.6-30 per cent cotyledonary tissue and 19-27 per cent embryonic axis induced somatic embryos in both the cultivars (Table 2). However, the number of explants producing somatic embryos increased with the addition to Kanamycin in the medium. Aly *et al.* (1992) used 100 μ M silver nitrate and 500 mg/l cefotaxime to obtained somatic embryos from *J. regia* and reported that antibiotics stimulated walnut somatic embryo production.

Somatic embryos, in walnut were produced from dark brown coloured callus formed on the explants cultured in DKW with various additives. Comu (1989) also reported clusters of somatic embryos from dense callus in black walnut hybrid. However, Tulecke and McGranahan (1985) reported somatic embryos in *J. hindsii* and *J. regia* directly from the explants without an intervening callus. Neuman *et al.* (1993) reported in *J. nigro* that somatic embryos formed both directly from original cotyledon explants and indirectly via callus and probably, there was either differences among walnut genotypes regarding direct and indirect somatic embryogenesis or similar pathways were followed which could not be sufficiently characterized histologically. In the present investigation, apparently normal bipolar somatic embryos have been obtained from two cultivars of walnut. However, since, the explant source is the immature embryo which is the result of open pollination, the culture might represent varying genotypes. This difference could be seen from differential response of explants to culture

conditions. Attempts are being made to regenerate plants from somatic embryos.

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QUARANTINE PROCESSING OF EXOTIC SORGHUM GERMPLASM DURING 1976-1998

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Out of 4261 seed samples of Sorghum imported from 17 different countries during 1976-1998 (14% of total sorghum germplasm imported), five hundred eighty eight samples of *Sorghum* spp were found infested with 57 different species of fungi. This communication reports potential pathogenic fungi of considerable importance intercepted during course of quarantine investigations.

Key words : Sorghum, germplasm, pathogenic fungi, quarantine

Sorghum is a major staple food in the semi-arid and tropical regions. There are 44 fungal pathogens reported to be associated with seeds of *Sorghum* spp, (Richardson, 1990). Though exchange of plant genetic resources (PGR) is a key factor in crop improvement programme, there is always an associated risk of inadvertent spread of pests and pathogens into new areas.

During last 23 years (1976-1998), four thousand two hundred and sixty one (4261) seed samples of sorghum germplasm were received from 17 countries (Table 1). All the seed samples were first subjected to dry seed examination under the stereo-binocular microscope for the presence of discoloured or deformed seeds, mycelial growth or fungal fructifications. The seeds were then subjected to blotter test and incubated for seven days at $20^{\circ}\text{C} \pm 1$ under alternating cycles of 12 hr. light and darkness.

During the examination, 588 samples were found infected with 57 different species of fungi (Table 2). Some of the potential pathogenic fungi of considerable economic significance intercepted were *Botrytis cinerea* (grey mould fungus);

Curvularia lunata, *Fusarium moniliforme*, *Phoma sorghina* (grain mould fungi), *Colletotrichum graminicola* and *Colletotrichum gloesporioides* (stalk rot, red leaf, anthracnose), *Gloeocercospora sorghi* (zonate leaf spot); *Drechslera maydis* (target spot), *Drechslera sorokiniana* (seedling blight), *Macrophomina phaseolina* (charcoal rot, seedling blight) and *Periconia circinata* (milo disease, crown rot root rot) (Khetarpal and Ram Nath, 1982; Ram Nath *et al.*, 1986). Most of the fungi recorded were important from quarantine point of view as they are reported to be seed-borne and seed-transmitted on sorghum or other crops (Richardson, 1979 and 1990).

D. sorokiniana, *D. turcica*, *F. moniliforme*, *F. solani* and *G. sorghi* etc. are reported to have a wide host range including cereals, millets and vegetable crops. Interception of race "T" of *Drechslera maydis* on sorghum seeds from USA (Ram Nath *et al.*, 1973) was very significant as in 1979 this race attacked cytoplasmic male sterile lines of maize in USA, reaching to an epiphytic proportion and the losses were estimated to be one billion US dollars in that year (Tatum, 1971).

Table 1. Sorghum germplasm processed during 1976-1998

Source/Country	No. of samples processed	No. of samples infected
Argentina	4	1
Australia	10	2
Egypt	291	0
Hungary	49	0
Japan	18	0
Kenya	139	3
Nigeria	502	74
Philippines	76	76
S. Korea	3	2
Senegal	5	0
Sri Lanka	2	0
Sudan	106	3
Tanzania	1	0
Turkey	13	0
USA	2825	425
USSR	174	1
Zimbabwe	44	1
Total	4261	588

Botrytis cinerea, *Brachyspora* spp., *Cercospora* sp., *Curvularia andropogonis* C. Crepinii, *C. deightoni*, *C. oryzae*, *Drechslera papendorfii* *Phaeotrichoconis crotolariae*., *Phomopsis* sp., *Pithomyces* sp. *Pyrenochaeta* sp. and *Ulocladium* sp. have not been reported to be seed-borne in sorghum, however these are known to be potential pathogens in other crops (Richardson, 1990). In India, *Drechslera turcica*, *Colletotrichum graminicola* and the grain mould fungi like *Phoma* spp., *C. lunata* and *F. moniliforme* are considered as pathogens of major economic significance (Ravindranath 1978). *C. lunata*, *F. moniliforme* and *Phoma sorghina* causal organisms of seed mould are reported to be the major factor in the deterioration of the seed quality, loss in viability and germination (Singh *et al.*, 1989). The presence of physiologic races in some other pathogens like *D. sorokiniana* (Robles. 1949) and

D. turcica (Lefebvre, 1945) have implications of international spread. It is evident that the highest number of seed samples i.e. 2825 were imported from USA, however the highest number of samples i.e. 425 infected with 33 different fungal species were also from USA. Hence it could be inferred that larger the seed import larger is the risk associated with. Introduction of pathogenic races or pathotypes to regions where local cultivars are resistant to endemic races of the same species may have serious consequences (Neergaard, 1977), therefore, significance of these interceptions increases manifold.

Table 2. Pathogenic fungi intercepted in imported sorghum germplasm

Fungi Intercepted	Source/Country
<i>Alternaria longissima</i> Deighton & McGarvie	Nigeria, USA
<i>Arthobotrys</i> sp.	USA
<i>Botrytis cinera</i> Pers. Ex. Pers.	USA
<i>Brachyspora dingliya</i> Hughes	Nigeria
<i>Brachyspora</i> sp.	Nigeria, USA
<i>Cercospora</i> sp.	Nigeria
<i>Chaetomium</i> sp.	Nigeria, USA
<i>Choenophora</i> spp.	Philippines
<i>Colletotrichum gloeosporioides</i> (Penz.) Sacc	Nigeria, USA
<i>Colletotrichum graminicola</i> (Ces.) Wils	Nigeria, S. Korea, USA
<i>Curvularia andropogonis</i> (Zimm.) Boedijn	Nigeria
<i>Curvularia clavata</i> Jain	Nigeria
<i>Curvularia crepinii</i> (Westend) Boedijn	Nigeria
<i>Curvularia cymbopogonis</i> (Dodge) Groves &	Nigeria
<i>Curvularia lunata</i> (Wakker) Boedijn	Nigeria, USA
<i>Curvularia oryzae</i> Bugnicourt	Nigeria, USA
<i>Curvularia penniseti</i> (Mitra) Boed.	Nigeria, USA
<i>Drechslera biseptata</i> (Sacc. & Roum.) Richardson	Nigeria, USA

<i>Drechslera hawaiiensis</i> (Bugnicourt) Subram. &	Nigeria
<i>Drechslera maydis</i> (Nisik) Subram. & Sherwin)	Philippines, Sudan, USA
<i>Drechslera rostrata</i> (Drechsler) Richardson	Nigeria, USA
<i>Drechslera sorghicola</i> (Lefebvre & Shrewin)	Kenya, Nigeria, USA, Zimbabwe
<i>Drechslera sorokiniana</i> (Sacc.) Subram. & Jain	Kenya, USA
<i>Drechslera turcia</i> (Pass) Subram. & Jain	Nigeria, USA
<i>Fusarium equiseti</i> (Corda) Sacc.	Nigeria, USA
<i>Fusarium fusarioides</i> Wr. & Rg.	Nigeria, Korea, USA
<i>Fusarium semitectum</i> Berk. and Rav.	Nigeria, USA
<i>Fusarium solani</i> (Mart.) App. & Wr.	Argentina, Nigeria, USA
<i>Gonatobotrys</i> sp.	USA
<i>Gloeocercospora sorghi</i> Bain & Edgerton ex Deighton	Kenya, Nigeria, USA
<i>Macrophomina phaseolina</i> (Tassi.) Goid	Kenya, Nigeria, USA
<i>Phaeotrichoconis crotolariae</i> (Salam & Rao)	Nigeria
<i>Phoma sorghina</i> (Sacc.) Boerema, Dorenbosch & Van Kest	Australia, Nigeria, S. Korea, Sudan, USA, Zimbabwe
<i>Phomopsis</i> sp.	USA
<i>Pithomyces</i> sp.	Nigeria
<i>Pyrenochaeta</i> sp.	Nigeria
<i>Ulocladium</i> spp.	Nigeria

The introduction of germplasm harboruring pathogens of economic significance can pose a threat to the sorghum improvement programme of the country. Detection of 588 infected samples contributing to about 14 per cent of the total

importance of sorghum germplasm emphasises the need of plant quarantine.

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MULTIPLE DISEASE RESISTANT REACTION TO BARLEY GERMPLASM UNDER NATURAL EPIPHYTOTIC CONDITION

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Four hundred forty one barley germplasm were screened under natural epiphytotic condition to find suitable sources of multiple resistance for major barley diseases such as yellow rust, brown rust, barley blight and cover smut. Ninety two lines were found free from all the four diseases and were characterised as highly resistant and can be utilized for evolving disease resistant varieties.

Key words : Barley, germplasm, epiphytotic, inoculation, multiple resistance

Barley is popularly grown in Himachal Pradesh due to its increased demand as well as low cost of cultivation. However, its yield potential is limited due to many maladies. Among these rusts, blights and smuts are most devastating. The yield losses due to yellow rust may be as high as 38 per cent under natural epidemics (Suryanarayan, 1979). Because of non-availability and popularity of chemical control, the resistant varieties are the best and the cheapest method of disease control. The present studies were carried out to find suitable sources of multiple resistance for major barley diseases such as yellow rust (*Puccinia striiformis hordiei*), Brown rust (*Puccinia hordei*), Barley blight (*Helminthosporium sativum*) and covered smut (*Ustilago hordei*).

A large number of cultivars/lines and exotic materials were sown in a single row plot of 3 meters length at Regional Research Station's Experimental Farm (HPKV) Bajaura, which is known as hot spot for barley diseases. This centre provides good feasibility for screening the germplasm of barley especially for yellow rust because disease appears in sufficient spectrum for

viable screening of germplasm. The incidence of different diseases on each entry was recorded on standard scales. The germplasm plot were screened 2-3 times during growth and development period for incidence of diseases during *rabi* 1997-98.

Out of 441 germplasm lines screened a total of 92 entries listed below, were found free from all the four diseases and were categorized as highly resistant.

BCU-6, BCU-4, BCU-43, BHS-150, BHS-325, BHS-362, BHS-279, BHS- 269, BHD-223, BHS-260, VLB-260, VLB-49, VLB-120, VLB-23, VLB-135, VLB-133, VLB-33, VIB-105, VLB-126, SP-48, SP-51, SP-38, BON-18, BON-169, BBM-160, BBM-1640, BBM-76, BGN-1BON, EIBGN-MRA-9, BVU-9, C-138, VLB-57, GHS-440, AZAD,H-23, BH-454, BH-441, DWR-17, UBE-215, H-19, BH-393, BH-455, DWR-12, HBL-339, HBL-166, Sonu, HBL- 150, HBL-113, HBL-246, AHAR-34, SONU-3-KR, HBL-316, HBL-105, HBL-258, HBL-313, HBL-69, HBL-103, IBON-11, IBON-12, IIWFBYT-20, IWFBON-99, IBON-53, IBON-26, IBON-179, IBON-10, IBON-129, USAD- 97, RD-2521, RH2456, RD-2484, RD-2431, BUDU-69, BYLYR-79, BCU- 220, BCU-22, BHAS-39, SP-37, SP-65, NBDSN-K-587, RD-3772, IBON-16, BYDB-45, IBYT-19, IBWFA-45, IBOW-11, IBON-34, IBON-33, BON- 52, BYDB-95, BYDV-123,

BYDV-1, IBON-55, IBON-36, IBYT-11, BEIGB-95-96-IBON, BEIGB-ISBOW-LRA-237, BEIGB-BSP-17, BEIGB-IBON-124, BOM (MON)-MRA-62, BEIGB-BH-425, BEIGB-ISBON-LRA-34 and, BEIG-ISBON-LRA-138.

These lines showed a good promise for multiple resistance for the barley diseases and can be utilized for evolving disease resistant varieties. The similar types of reports have also been reported earlier (DWR, 1998). Breeding for disease resistant cultivars has been taken up by different centres under All India Co-ordinated Barley Improvement Project (AICBIP) since its inception in 1966-67. Many sources of resistance to major disease of barley have been identified from the exotic as

well as indigenous barley germplasm and their genetics have also been studied (Luthra *et al.* 1991).

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PATHOGENIC FUNGI INTERCEPTED IN INTRODUCED OIL-SEEDS DURING 1976-98, THEIR SIGNIFICANCE AND CONTROL

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Introduced germplasm of oil-seed crops is one of the key factors in doubling the oil-seed production from 10.83 million tones in 1985-86 to 22.50 million tones in 1994-95. During last twenty- three years about 39,000 oil seed germplasm accessions comprising of *Brassica* spp., safflower, soybean, sunflower, castor etc. were introduced from various countries for crop improvement programmes. A large number of pathogenic fungi of quarantine significance were intercepted. The methods employed for salvaging and the significance of these interception is discussed.

Key words : Oilseeds, pathogenic fungi, quarantine

India shares about 20 per cent of the global area of oilseed production while in terms of production it contributes less than 10 per cent. To achieve self-reliance in oil production, New Policy on Seed Development (NPSD) came into force on October 1st, 1988 and a free access to worldwide germplasm of oilseeds was one of the key factors in doubling the oilseed production from 10.83 million tones in 1985-86 to 22.50 million tones in 1994-95. However, such liberalization in the exchange of Plant Genetic Resources (PGR) always carried the risk of introducing exotic pests and pathogens or their more virulent strains in the country.

During the last 23 years (1976-1998) National Bureau of Plant Genetic Resources has introduced 39,169 seed-samples of different soil-seeds viz. *Brassica* spp. (6541); *Glycine* spp. (15,542); *Helianthus* spp. (6490); *Carthamus* spp. (6240); *Linum* spp. (505); *Sesamum* spp. (3,021), *Ricinus* spp. (526); *Arachis hypogaea* (235); *Cocos nucifera* (1), *Elaeis guineensis* (66) and Olive spp. (2) from different countries.

Quarantine processing of introduced germplasm begins with the examination of seeds under a stereo-binocular microscope for the presence of mal formed, deformed and discoloured seeds, fungal mycelium, fructification, rust spores and oospore crust of downy mildew etc. Seed samples of sunflower and soybeans were subjected to washing test to detect rust and downy mildew, respectively. Unhealthy looking seeds were subjected to Blotter test and incubated at 20 (± 1)°C for seven days. The fungal growth and colonies developed were examined on the eighth day under the stereo-binocular microscope. Infected samples were salvaged by subjecting to appropriate treatments e.g. hot water treatment, ethyl alcohol wash or pesticide dressing.

Seed samples when examined under the stereobinocular microscope showed certain characteristic symptoms indicating the presence of pathogenic fungi. Purple stain on the surface of soybean seed indicated the possible presence of *Cercospora kikuchii* (Mats. & Tomoy) M.W. Gardner. The dull white crust on the surface of

soybean seed under stereoscopic examination and washing test revealed masses of hyaline to light brown, thick and smooth walled oospores of *Peronospora manshurica* (Naum.) Syd., Out of the total 15,542 samples of soybean, 1,716 samples (11%) showed the presence of *P. manshurica* the downy mildew fungus (Mukewar *et al.*, 1980; Agarwal and Singh, 1998). The interception of *P. manshurica* is of high quarantine significance as the pathogen is yet not reported from India. Presence of 33 physiologic races in USA (Li *et al.* 1992), 21 in Poland (Marcinkowska, 1987) and long periods of viability of oospores in the seed (pathak *et al.*, 1978) further add to the problem. Its importance further amplifies with the interception of this pathogen from Malaysia (Agarwal and Khetarpal, 1985) and Indonesia (Anitha *et al.*, 1993) from where this was hitherto unreported.

Safflower seeds showed the presence of small brown coloured teleutospores of *Puccinia carthami* Corda on the seed surface (Agarwal *et al.*, 1982). Of the total safflower samples analysed, 83 per cent (5168) showed the presence of rust. *P. carthami* is reported to have caused serious epiphytotics in USA in 1949-50 (Thomas, 1952). Thus presence of *P. carthami* in safflower samples of such diverse germplasm (collected by USDA from a number of countries) is of quarantine importance as the pathogen is known to have a number of races (Thomas, 1955). Likewise, washing test revealed the presence of the uredo- and teleutospores of *Puccinia helianthi* in sunflower seeds. Out of 6490 seed samples examined, rust spores were detected in 309 samples.

Examination of plates after incubation showed a large number of fungi on various crops (Ram Nath *et al.*, 1981 and 1985; Majumdar *et al.*, 1991). The details of the infected samples and the fungi intercepted during examination is given in Tables 1-5. Some of the major fungi detected in the blotter test are *Cercospora kikuchii* (purple

Table 1. Fungi intercepted on Introduced Brassica spp.

Country	No. of samples received (found infected)	Alternaria brassicae	Alternaria brassicicola	Fusarium solani	Phoma lingam
Belgium	25 (6)	-	6	-	-
Canada	439 (128)	47	57	1	37
China	44 (6)	-	2	4	-
Denmark	46 (12)	-	11	1	-
Ethiopia	36 (2)	2	2	-	-
Finland	9 (6)	-	-	6	-
France	92 (11)	6	11	9	-
Germany	279 (2)	-	2	-	-
Holland	76 (20)	-	19	1	-
Hungary	18 (2)	-	2	-	-
Italy	187 (27)	9	-	-	18
Japan	46 (10)	-	10	-	-
Korea	37 (8)	-	8	-	-
Sweden	234 (113)	69	103	6	1
Taiwan	775 (149)	14	138	12	1
U.K.	1269 (125)	13	111	5	6
USA	2287 (601)	3	589	5	4
USSR	151 (2)	-	1	-	1
Others	491 (0)	-	-	-	-
Total	6541 (1230)	163	1072	44	67

Apart from the fungi listed, *Alternaria raphani* (7) and *Alternaria solani* (1) from Canada and *Botrytis cinerea* (1) from Sweden were also detected.

blotch), *Colletotrichum* spp. (anthracnose), *Phomopsis sojae* Lehman (pod & stem blight), *Ascochyta sojicola* Abram. (leaf spot) on *Glycine* spp; *Phoma lingam* (Tde ex Fr.) Desm. (black leg), *Alternaria brassicae* (Berk.) Sacc. and *Alternaria brassicicola* (Schw.) Wilts (leaf spot) on *Brassica* spp., *Corynespora cassicola* (Berk. & Curt.) Wei the blight fungus on safflower, *Fusarium solani* (Mart.) Sacc. the wilt fungi was detected on safflower, *Brassica* spp, soybean, sunflower,

Table 2. Pathogenic fungi intercepted in introduced seeds of *Carthamus* spp.

Country	No. of samples received (found infected)	Puccinia carthami	Alternaria carthami
Australia	94(47)	37	10
Canada	19(3)	3	-
China	50(50)	50	-
Ethiopia	14(3)	3	-
Germany	53(4)	-	-
Greece	11(5)	5	-
Italy	59(17)	16	-
Singapore	1586(1586)	1586	-
Turkey	22(9)	6	-
USA	4205(3464)	3462	-
Others	127(0)	-	-
Total	6240(5188)	5168	10

Apart from these fungi, *Fusarium solani* (3), *Pestalotia* sp. (1) from Germany; *Alternaria zinniae* (1) and *A. solani* (1) from Turkey; *Botrytis cinerea* (2) from USA and *Drechslera sorokiniana* (1) from Italy were also detected.

sesamum and oil-palm seeds. The grey mould pathogen, *Botrytis cinerea* Pers. ex. Pers., a common saprophyte in the European countries, which caused heavy losses to chickpea crops in Bihar, U.P., Haryana and Punjab (Laha and Grewal, 1983) was detected on seeds of sunflower, safflower, soybean and *Brassica*. *Drechslera sorokiniana* (Sacc.) Sub & Jain the causal organism of seedling blight in many crops was detected in soybean, a non-host crop. Most of the fungi intercepted on various crops are reported to be seed borne and seed transmitted (Richardson, 1990).

Several species of *Alternaria* were intercepted on seeds of various crops. *A. brassicae* detected on seeds of *Brassica* spp. has become a major problem due to its spread from rape-seed at harvest to seeds of other *Brassica* spp.. Chahal and Kang (1979) reported internal seed borne

Table 3. Pathogenic Fungi intercepted in introduced seeds of *Glycine* spp.

Country	No. of samples received (found infected)	Pero-nopora manshurica	Cercospora kikuchii	Colleto-trichum dematium	Colleto-trichum glycine	Phomopsis sojae
Australia	296(1)	1	-	-	-	-
Belgium	3(1)	1	-	-	-	-
Brazil	79(11)	11	-	-	-	-
Indonesia	43(1)	1	-	-	-	-
Isreal	9(2)	2	-	-	-	-
Italy	21(1)	1	-	-	-	-
Japan	24(2)	2	-	-	-	-
Korea	61(18)	18	-	-	-	-
Malaysia	6(6)	-	-	-	-	-
Nigeria	860(1)	-	-	1	-	-
Poland	12(2)	2	-	-	-	-
Russia	35(5)	5	-	-	-	-
Taiwan	2330(216)	167	5	16	2	17
Thailand	20(3)	1	-	2	-	-
USA	8478(1762)	1492	116	47	9	64
USSR	90(3)	3	-	-	-	-
Zimbabwe	206(3)	3	-	-	-	-
Others	2969(0)	-	-	-	-	-
Total	15,542 (2038)	1716	121	66	11	81

In addition to the fungi listed in the table, following fungi were also intercepted. *Aschochyta sojicola* (10); *Botrytis cinerea* (2); *Colleto-trichum gloeosporioides* (2); *Fusarium solani* (9); *Pestalotia* sp. (1); *Sclerotinia sclerotiorum* (1) and *Verticillium albo-atrum* (9) from USA. *Drechslera sorokiniana* (1) from Taiwan; *Macrophomina phaseolina* from Taiwan (6) and USA (1); *Rhizoctonia solani* from Taiwan (2) and USA (3); *Fusarium poae* from Poland (1) and USA (10).

infection of *A. brassicae* at levels of 59 per cent in India. *Alternaria carthami* Chowdhury, *Alternaria solani* Sorauer and *Alternaria zinniae* M.B. Ellis the leaf spot pathogens were detected on safflower seeds.

The Purple blotch pathogen, *Cercospora kikuchii* had devastated the soybean cultivation in

Table 4. Pathogenic fungi intercepted in introduced seeds of *Helianthus* spp.

Country	No. of samples received (found infected)	<i>Puccinia helianthi</i>	<i>Botrytis cinerea</i>	<i>Verticillium albo-atrum</i>	<i>Fusarium avenaceum</i>	<i>Fusarium solani</i>
Australia	310(34)	33	-	-	-	-
Belgium	3(1)	1	-	-	1	-
Bulgaria	81(7)	6	-	1	-	-
Canda	262(13)	13	-	-	-	-
Egypt	118(8)	-	-	-	-	-
France	230(23)	21	1	1	-	1
Germany	19(1)	-	-	-	-	1
Hungary	238(15)	15	-	-	-	-
Italy	1595 (35)	7	24	2	-	1
Romania	30(1)	-	-	1	-	-
Spain	44(4)	1	-	-	-	1
USA	3295(211)	200	8	-	3	1
USSR	129(10)	10	-	-	-	-
Yugoslavia	30(2)	2	-	-	-	-
Others	106(0)	-	-	-	-	-
Total	6490(365)	309	33	5	4	6

Apart from these fungi, *Phaetrichoconis* sp. from USA (1); *Pestalotia* sp. from Australia (1); *Alternaria zinniae* from Italy (1); and *Diplodia* sp. From Egypt (8) were also detected.

USA during 1978 by reducing yield to the extent of 36 million metric tonnes. Out of 8478 samples received from USA, 116 were found to be infected with this pathogen.

Apart from the interceptions listed in the tables, 16 samples of *Linum* spp. were found infected with *Colletotrichum dematium* (Pers. ex Fr) Tul. from Hungary (8 samples) and Poland (1); *Colletotrichum gloeosporioides* (Penz.) Sacc. from USA (4) : *Rhizoctonia solani* Kuhn from Poland (3). Sixty-six samples of *Ricinus* spp. were infected with *Alternaria ricini* (Yoshii) Hansford from France (1), Italy (1), USA (55) and USSR (8), and *Phomopsis* spp. from U.K. (1).

Table 5. Pathogenic fungi intercepted on introduced seeds of *Sesamum* spp.

Country	No. of samples Received (Found infected)	<i>Alternaria sesami</i>	<i>Cercospora sesamicola</i>	<i>Macrophomina phaseolina</i>	<i>Fusarium solani</i>
China	30(3)	3	-	-	-
Israel	477 (19)	11	-	4	4
Korea	14 (9)	6	-	-	-
Philippines	30 (2)	2	-	-	-
Singapore	1728 (10)	10	-	-	-
South Africa	17 (2)	-	1	1	-
Thailand	30 (10)	1	-	8	1
USA	301 (69)	62	5	-	-
Others	394 (0)	-	-	-	-
Total	3021(124)	99	6	13	5

In addition to these, other fungi intercepted were *Phoma lingam* (1) and *Rhizoctonia bataticola* (1) from USA; *Corynespora cassicola* (9) from Korea

Thus, in the quarantine processing of 39,169 samples of different oil-seeds, 9027 seed samples (23 per cent) were found infected. All the seeds showing symptoms of discolouration, deformation and presence of fungal mycelium and fungal fructifications under stereobinocular microscope were removed to minimize the inoculum. Seed samples found infected with *Alternaria brassicae*, *A. brassicicola*, *A. raphani*, *A. solani*, *A. zinniae*, *A. carthami*, *A. sesami*, *A. ricini*, *Phoma lingam* and *Fusarium solani* were salvaged using hot water treatment at 50 C for 20 minutes. Ethyl alcohol was (Agarwal *et al.* 1990) was given to seeds of safflower and sunflower infected with rusts i.e. *Puccinia carthami* and *P. helianthi*, respectively. Chemical treatment with thiram and Bavistin (1:1) mixture was given for rest of the infected samples.

Almost 23 per cent of the introduced oil-seed germplasm were found infected with various seed-borne fungi. About 81 per cent of the

infected germplasm were salvaged. Soybean seed samples infected with *P. manshurica* amounting to 4% of the total introduction were rejected and burnt. Interception of pathogenic fungi, some of which are of high quarantine significance, emphasizes the role of quarantine in introduction of germplasm.

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PLANT GERMPLASM REGISTRATION NOTIFICATION

On the recommendations of crop specialists, the germplasm registration committee of ICAR in its Vth meeting on 15th November 1999 at NBPGR approved the registration of following fifteen germplasm lines of the 69 proposals received:

INGR 99023 is a low ODAP, white flowered, white seeded and high yielding grasspea (*Lathyrus sativus*) line designated Bio-208. This somaclonal variant has been developed from cultivar P-24 by SL Mehta, PK Roy, GK Barat, IM Santha and K Ali at Division of Biochemistry, IARI, New Delhi.

INGR 99024 is a cytoplasmic male sterile line of mustard (*Brassica juncea*), carrying the cytoplasm of *Diplotaxis eruroides*. It is developed by intergeneric hybridisation between *Diplotaxis eruroides* x *B. campestris* and back crossing the progeny using the pollen of *B. juncea*. It is developed by Meghna Malik, Poonam Vyas, NS Rangaswamy and KR Shivanna at Department of Botany, University of Delhi, Delhi.

INGR 99025 is an early flowering variant (31-33 days) of rape seed (*Brassica napus*), carrying the cytoplasm of *Erucastrum gallicum*. It is a result of intergeneric hybridisation between (*Erucastrum gallicum* x *B. juncea*) x *B. napus* followed by two back crosses using the pollen of *B. napus* and then by selfing (BC2F5). It was developed by GU Rao, AK Pradhan and KR Shivanna at Department of Botany, University of Delhi, Delhi.

INGR 99026 is a useful variant of Ethiopian mustard (*B. carinata*) showing *B. juncea* type branching and resembling *B. carinata* in other features. It is a result of repeated backcrossing of alloplasmic (*Erucastrum gallicum* x *B. juncea*) with pollen of *B. carinata* developed by GU Rao,

AK Pradhan and KR Shivanna at Department of Botany, University of Delhi, Delhi.

INGR 99027 is a cytoplasmic male sterile line of mustard (*B. juncea*), carrying the cytoplasm of *Diplotaxis siifolia*. This CMS line resembles *B. juncea* cv Pusa Bold and is a result of intergeneric hybridisation between (*Diplotaxis siifolia* x *Brassica juncea* cv Pusa Bold) followed by the production of back cross generation (BC8) with the pollen of cultivar Pusa Bold. This CMS line is developed by GU Rao, Vinita Batra-Sarup, S Prakash and KR Shivanna at Department of Botany, University of Delhi, Delhi.

INGR 99028 is a genetic male sterile mutant of pigeonpea (*Cajanus cajan*) designated Pant A-225. It is a spontaneous mutant of UPAS-120 selected by SB Verulkar, DP Singh and GC Bajpai at GB Pant Univ of Agril & Tech Pantnagar.

INGR 99029 is a hybrid of *Camellia sinensis* (L) x *C. assamica* (Masters) designated Clone TV 1 (19/29/13). The clone was selected from Stock No 19/29 growing at the Tocklai Experimental Station, Jorhat. It is a selection from the progeny of Inter-jat hybridization between Assam and China hybrids made by Department of Botany, Tocklai Experimental Station, Jorhat, Assam. Information about the clone was generated by the Botany, Biochemistry and Tea Tasting Departments of the station.

INGR 99030 is a tea (*Camellia assamica*) designated Clone TV2 (20/23/1). It is a selection from the progeny of stock No 20 bush No 23/1 growing at the Tocklai Experimental Station, Jorhat. It is developed by hybridization of Assam and China hybrids. Information about the clone was generated by the Botany, Biochemistry and Tea Tasting Departments of the station.

INGR 99031 is a tea (*Camellia assamica*) designated Clone TV 17(202/17). It is a selection from the progeny of stock No 202, bush No 17 growing at the Tocklai Experimental Station, Jorhat. The progeny was derived by a cross between TV1 x 19/31/14. Selection of the bush 202/17 was followed by the testing of its vegetatively propagated progenies in field and laboratory.

INGR 99032 is a tea (*Camellia assamica* ssp *lasiocalyx*) clone of Indo-China origin designated Clone TV 19(107/14). It is a selection from the progeny of stock No 107, bush No 14 growing at Borbheta Experimental tea Estate at Department of Botany Tocklai Experimental Station, Jorhat, Assam. Information about the clone was generated by the Botany, Biochemistry and Tea Tasting Departments of the station.

INGR 99033 is a tea (*Camellia assamica* ssp *lasiocalyx*) clone of Indo-China origin designated Clone TV 20 (468/3/13). It is a selection from the progeny of stock No 468 bush No 3/13 maintained and developed at Department of Botany, Tocklai Experimental Station, Jorhat, Assam. Information about the clone was generated by the Botany, Biochemistry and Tea Tasting Departments of the station.

INGR 99034 is a high protein and high grain weight wheat (*Triticum durum*) designated RD20. It is an interspecific derivative developed from HD 4502 //T. *turgidum* 46432//Raj 911/3/T. *turgidum* 44 by Bhanwar Singh and

MK Upadhyay at Division of Genetics IARI, New Delhi.

INGR 99035 is a high yielding, fine grain, dwarf line of paddy (*Oryza sativa*) developed with alternative dwarfing source and designated PNR 519 (IET 9944). It has wider adaptability in irrigated as well as rainfed ecosystems and has the potential of introducing greater diversity in rice farming. It is developed from Tainan 3 Mutant/Basmati 370//PNR 417-3(PNR 417-3 is an induced semi-dwarf mutant from Basmati 370, both have different dwarfing gene than DGWC). The line has been developed by SN Chakrabarti at Division of Genetics, IARI, New Delhi.

INGR 99036 is an indeterminate, semi-spreading vine type round melon/tinda (*Praecitrullus fistulosus*) designated HT-10. It has a green foliage, round, bright fruit, tender and sparsely pubescent, tolerant to downy mildew and root rot wilt complex. It is a selection from segregating population of the cross Hisar Selection x 84#6 by MS Dahiya, KS Baswana and BK Nehra at the Department of Vegetable Crops, CCS HAU, Hisar.

INGR 99037 is an indeterminate, semi-spreading, medium tall, thornless brinjal (*Solanum melongena*) designated Hisar Jamuni (H-9). It produces better ratoon for spring crop, fruit colour is retained for a long time, less seed content, serve the purpose of long and round types. It is a selection from segregating population of Aushey x R-34 by G Kalloo, NK Sharma and KS Baswana at Department of Vegetable Crops, CCS HAU, Hisar.

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