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SPREAD OF SOUTH-WEST ASIAN CULTIVATED PLANTS AND THEIR WILD AND WEEDY RELATIVES TO SOUTH ASIA AND BEYOND

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Vavilov while advancing his theory on the centres of origin of cultivated plants assigned 83 plants to his Near-Eastern centre of origin. Of these, 15 are vegetable crops and 24 fruit crops. They belong to 32 genera. An examination of their distribution and variability show certain patterns. Some genera like *Lactuca*, *Pyrus*, *Prunus* and *Allium* show much variability in both the regions, south-west Asia and south Asia, and also in the intervening area. A few genera, *Ficus* in particular, show greater variability and distribution in south (and south-east) Asia, but the only cultivated fruit of this genus, *F. carica* is thought to have been domesticated in Asia minor. Few others, and notably *Punica* do not show much interspecific variability, but considerable intraspecific variability. This paper elucidates such information which is useful in determining priorities and strategies for biological conservation of the species. It also gives insight into the mechanisms involved in speciation and evolution of different taxa.

Key words : Cultivated plants, wild relatives, origin, spread/distribution pattern, *Lactuca*, *Pyrus*, *Zizyphus*, *Vitis*, *Berberis*, *Ficus*, *Punica*, *Petroselinum*, *Eruca sativa*

The origin and spread of cultivated plants in the world has been the subject of speculation from very early times, from the time of Theophrastus. De Candolle (1886) is credited with having given a scientific and holistic approach to this subject. He used the then available information from diverse sources as archaeology, folklore, ancient travelogues, philology and botany to develop his postulates on the origins and distribution of about 400 cultivated plants. Subsequent to this, the science of genetics and biosystematics had their origin, and considerable information was obtained from these areas of study on crop plants origin. And simultaneously, more and more evidences were also getting accumulated in the areas of archaeology, prehistory and plant geography. The Russian botanist N.I. Vavilov (1926) propounded his classical theory on the origin of cultivated plants based on these aspects and the

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observations made by him in his extensive travels. Vavilov's concepts on the centres of origin and variation of cultivated plants have been largely accepted, though some variations of the main theme have been proposed by certain latter-day evolutionists. We shall not go into these details in the present paper.

The Near-Eastern centre

Vavilov (1926) had identified eight centres of origin of cultivated plants in the world. His fourth Centre was the Near-Eastern Centre, which occupies the Near East, including the interior of Asia Minor, the whole of Transcaucasia, Iran and the highlands of Turkmenistan. He assigned to this Centre 83 cultivated plants belonging to the broad categories of grain crops (18), forage plants (8), oil plants (9), alkaloid and tannin plants (7), vegetables (15), fruits (24), and spices and dye plants (2). The fruit and vegetable plants that have been proposed to have originated in the Middle East Centre (Table 1) are discussed in this paper with regards to their occurrence in South Asia. Vavilov (*loc. cit.*) observed that the Near-Eastern Centre "is the most notable for its wealth of varieties of cultivated wheats, rye exists here in amazing diversity of forms, the accidental orchard fruits are concentrated here including the grape, pear, cherry, pomegranate, walnut, quince, almond and fig, ... species formation has been actively occurring here in several genera such as *Medicago*, *Pyrus* and *Amygdalus*, and to a considerable degree also in the wheats ..., the world's wealth of melons ..., and the leading forage crops, alfalfa, persian clover, a number of species of *Trigonella* and vetch, have also originated in the near East".

Origin and distribution of cultivated plants

Vavilov's centres of origin generally coincide with the ancient centres of civilization also. This is understandable because as the early man left his nomadic habits of hunting and food gathering and gradually adopted a sedentary habit, he initially chose river valley basins for his earliest settlements. He found that his needs steadily began to increase, and the food materials that he was able to gather from naturally occurring plants was inadequate to meet his full needs. He was thus compelled to take up cultivation gradually. For cultivation, he selected types having superior attributes as higher yield, better quality, better adaptability to the prevailing environment, and some resistance to the most serious diseases and pests affecting them. As the community's requirements increased steadily, he began to explore newer areas in search of more land for cultivation, and for newer species of plants to meet his increasingly varied requirements. Almost simultaneously, a process of commerce and barter trade began to develop. With this, trade and caravan routes also began to establish gradually.

The Near-Eastern centre of Vavilov is also an area of ancient civilization. So also is the south Asian region, Vavilov's Hindustani Centre. The Indian subcontinent has been known from prehistoric times for its wealth of spices, ivory, gold, precious stones, etc. Consequently, there developed active trade between the Near-East and South Asia. The ancient traders and explorers took various routes to reach south Asia from South-west Asia. The most important among these were the overland route across Mesopotamia and Khyber pass, and a land cum sea route covering the Arabian peninsula along the coast and then by sea. Even as trade and commerce began to establish, the settlers appear to have developed a process of exchange of plants in both directions. Alongwith the useful plants, weedy and ruderal plants also began to spread. This process occurred both by chance and by design.

Not all the species that are common to both the regions have moved in this manner. Some of the species complexes would have had wide distribution covering both the regions. Then, over a period of time, because of adverse climatological and other changes, their occurrence in some of the interfering areas might have disappeared to give rise to their presence in two or more discrete areas instead of continuously. The hot and humid climates prevailing in the tropical and subtropical regions or South Asia are not conducive to the preservation of biological material for long periods. Because of this, for studying the movement and occurrence of cultivated plants from south-west Asia to south Asia, it may be necessary to depend more on botanical and related evidences rather than on archaeology.

Fruits and vegetable plants

The present status on the occurrence in south-west and south Asia of 32 genera of plants to which the fruit and vegetable plants (which Vavilov had proposed) to have originated in the Middle-East are given in Table 1. Information on the size of these plant genera and their distribution are also included in the table. These have been compiled from various sources (Hooker, 1872, 1887; Hutchinson, 1964 - 1967; Rendle 1938; Simmonds, 1976; Wlth. India, 1948 - 1976; Zeven and de Wet, 1982).

Pattern of distribution

An examination of the data shows certain interesting trends. Firstly, the movement of plants might have been a two-way process, even though this was being carried out by traders, conquerors and settlers. Prehistoric evidences show that greater movement took place from south-west Asia to south Asia. Secondly, some of the plants which had their origin in the Middle East have not got established in south Asia. This may have happened for various reasons

Table 1 : Distribution of wild and weedy species of cultivated plants in south west Asia and south Asia

Sl. No.	Cultivated plants originated in south west Asian Centre	Species present in both the centres	Species present in only south-west Asian Centre	Species present in only South Asian Centre	Remarks
1.	2.	3.	4.	5.	6.
1.	<i>Cucumis melo</i> L., <i>C. flexuosus</i> L., <i>C. sativus</i> spp. <i>antisiticus</i> Gabarev	2 spp., <i>C. callosus</i> , <i>C. prophetarum</i>	One sp., <i>C. chali</i>	2 spp., <i>C. hystrix</i> , <i>C. sitosus</i>	ca. 70 spp., warmer parts of the world, especially, Africa
2.	<i>Cucurbita pepo</i> L.	2 spp., <i>C. maxima</i> , <i>C. moschata</i>	nil	one sp., <i>C. ficifolia</i>	ca. 30 spp., tropics and subtropics
3.	<i>Lepidium sativum</i> L.	2 spp., <i>L. latifolium</i> <i>L. ruderae</i>	12 spp., <i>L. ancheri</i> , <i>L. caespitosum</i> , <i>L. campestre</i> , <i>L. cartilagineum</i> , <i>L. chulepense</i> , <i>L. hirtum</i> , <i>L. lyratum</i> , <i>L. nebrodense</i> , <i>L. perfoliatum</i> , <i>L. spinosum</i> , <i>L. vesicartum</i> , <i>L. graminifolium</i>	3 spp., <i>L. apetalum</i> , <i>L. capitatum</i>	ca. 150 spp.
4.	<i>Brassica campestris</i> L. subsp. <i>oleifera</i> Metz., <i>B. juncea</i> Czern. var. <i>sarekiana</i> Sinsk., <i>B. nigra</i> L. var. <i>pseudocampestris</i> Sinsk.	nil	4 spp., <i>B. cretica</i> , <i>B. deflexa</i> , <i>B. elongata</i> , <i>B. tournefortii</i>	2 spp., <i>B. napus</i> , <i>B. rapa</i>	More than 200 spp., world-wide, but more in north temperate zone, specially in Mediterranean region

(Contd. from p. 4)

1.	2.	3.	4.	5.	6.
5.	<i>Beta vulgaris</i> L.	nil	6 spp., <i>B. adanensis</i> , <i>B. corolliflora</i> , <i>B. lomatogana</i> , <i>B. macrorrhiza</i> , <i>B. maritima</i> , <i>B. trigyna</i>	One sp., <i>B. palonga</i>	ca.6 spp., Europe and Mediterranean region
6.	<i>Daucus carota</i> L.	nil	6 spp., <i>D. aureus</i> , <i>D. broteri</i> , <i>D. conchitae</i> , <i>D. guttatus</i> , <i>D. involucreatus</i> , <i>D. littoralis</i>	nil	ca.60 spp., Europe, Asia, Africa and America
7.	<i>Eruca sativa</i> Mill. var. <i>orientalis</i> Sinsk.	nil	nil	one sp., <i>E. vesicaria</i>	ca.6 spp., Mediterranean and north-east Asia
8.	<i>Allium cepa</i> L., <i>A. porrum</i> L.	2 spp., <i>A. ascalonicum</i> , <i>A. sativum</i>	ca.77 spp.	ca.35 spp.	ca.450 spp., northern hemisphere
9.	<i>Petroselinum crispum</i> (Miller) A.W. Hill, <i>P. hortense</i> Hoff.	nil	nil	nil	ca.5 spp., Europe and Mediterranean region.
10.	<i>Lactuca sativa</i> L.	4 spp., <i>L. crambifolia</i> , <i>L. orientalis</i> , <i>L. serriola</i> , <i>L. undulata</i>	18 spp.	21 spp.	ca.100 spp., temperate Eurasia with an extension to tropical south Africa
11.	<i>Portulaca oleracea</i> L.	nil	One sp., <i>P. sativa</i>	3 spp., <i>P. pilosa</i> , <i>P. quadrifida</i> , <i>P. wightiana</i>	ca.200 spp., tropics and subtropics

(Contd. from p. 5)

1.	2.	3.	4.	5.	6.
12.	<i>Ficus carica</i> L.	nil	5 spp., <i>F. jappanis</i> , <i>F. palmata</i> , <i>F. pseudosycamoros</i> , <i>F. sycamoros</i> , <i>F. vengalensis</i>	18 spp., <i>F. amplissima</i> , <i>F. amplocarpa</i> , <i>F. angulata</i> , <i>F. andamanica</i> , <i>F. arnottiana</i> , <i>F. costata</i> , <i>F. dalhousiae</i> , <i>F. diversiformis</i> , <i>F. ferguseni</i> , <i>F. mollis</i> , <i>F. nepalensis</i> , <i>F. neriofolia</i> , <i>F. nervosa</i> , <i>F. guttata</i> , <i>F. subincisa</i> , <i>F. trimenil</i> , <i>F. tsjakela</i> , <i>F. beddomii</i>	ca. 850 spp., tropical and subtropical regions, more in south and south- west Asia
13.	<i>Punica granatum</i> L.	nil	nil	nil	2. spp., Balkan peninsula to Himalayas
14.	<i>Malus pumila</i> Mill.	one sp., <i>M. sylvestris</i>	nil	3 spp., <i>M. baccata</i> , <i>M. sikkimensii</i> , <i>M. transitoria</i>	ca. 35 spp., northern temperature region
15.	<i>Pyrus communis</i> L.	nil	9 spp., <i>P. amygdaliformis</i> , <i>P. anatolica</i> , <i>P. boissieriana</i> , <i>P. bulgarica</i> , <i>P. elaeagnifolia</i> , <i>P. haktiarica</i> , <i>P. salicifolia</i> , <i>P. serecea</i> <i>P. valiriki</i>	11 spp., <i>P. arachnoidea</i> <i>P. cashimiriana</i> , <i>P. expansa</i> , <i>P. foliolosa</i> , <i>P. hedlundii</i> , <i>P. pashia</i> , <i>P. rhamnoides</i> , <i>P. theifera</i> , <i>P. ursina</i> , <i>P. wightii</i> <i>P. wenzigiana</i>	ca. 40 spp., temperate Eurasia

(Contd. from p. 6)

1.	2.	3.	4.	5.	6.
16.	<i>Cydonia oblonga</i> Mill.	nil	nil	nil	Monospecific genus, east Asia Minor, Caucasus, north Iran and central Asia
17.	<i>Prunus armeniaca</i> L. <i>P. cerasus</i> L., <i>P. divaricata</i> Led., <i>P. padus</i> L.	one sp., <i>P. cerasifera</i>	3 spp., <i>P. cocomila</i> , <i>P. kurdica</i> , <i>P. spinosa</i>	37 spp	ca. 200 spp., most common in temperate and subtropical parts of northern hemisphere
18.	<i>Cerasus avium</i> (L.) Moench	nil	7 spp., <i>C. angustifolia</i> , <i>C. bractypefolia</i> , <i>C. hippophaioides</i> , <i>C. incana</i> , <i>C. mahaleb</i> , <i>C. microcarpa</i> , <i>C. prostrata</i>	nil	ca. 140 spp., northern temperate region
19.	<i>Amygdalus bucharica</i> Korsh., <i>A. communis</i> L. <i>A. fenzliana</i> Korsh., <i>A. scoparia</i> Spach., <i>A. spinosissima</i> Bge	nil	13 spp. <i>A. arabica</i> , <i>A. balansae</i> , <i>A. caraductorum</i> , <i>A. graca</i> , <i>A. insveta</i> , <i>A. korshinskyi</i> , <i>A. lycioides</i> , <i>A. orientalis</i> , <i>A. pavotii</i> , <i>A. ramonesii</i> , <i>A. trichamygdalus</i> , <i>A. webbi</i> , <i>A. wandeltooi</i>	nil	ca. 40 spp., Mediterranean region to central China
20.	<i>Laurocerasus officinalis</i> Roem. (included under <i>Prunus</i> by Kakuan, 1965)	nil	nil	nil	ca. 75 spp., tropical and temperate Asia, and America with distribution to tropical Africa and Madagascar

(Contd. from p. 7)

1.	2.	3.	4.	5.	6.
21.	<i>Mespilus germanica</i> L.	nil	nil	one sp., <i>M. microphylla</i>	ca. 20 spp., south-east Europe to central Asia.
22.	<i>Juglans regia</i> L.	nil	nil	nil	ca. 15 spp., temperate to subtropical to northern hemisphere also in N. and S. America.
23.	<i>Corylus avellane</i> L.	nil	nil	2 spp., <i>C. ferox</i> , <i>C. jacquemontii</i>	ca. 15 spp., north temperate zone
24.	<i>Castanea sativa</i> Mill.	nil	nil	One sp., <i>C. indica</i>	10 spp., temperate northern hemisphere
25.	<i>Zizyphus sativa</i> Gaertn.	nil	2 spp., <i>Z. jujuba</i> , <i>Z. zizyphus</i>	13 spp.	ca. 100 spp., chiefly Indo-Malayan, but spread into the Mediterranean region Africa, Australia and tropical America
26.	<i>Vitis vinifera</i> L.	nil	5 spp., <i>V. hissarica</i> , <i>V. hyrcanica</i> , <i>V. labrusca</i> , <i>V. orientalis</i> , <i>V. sylvestris</i>	4 spp., <i>V. jacquemontii</i> , <i>V. lanata</i> , <i>V. parvifolia</i> , <i>V. pedicellata</i>	ca. 70 spp., northern hemisphere
27.	<i>Pistacia vera</i> L.	2 spp., <i>P. eurycarpa</i> , <i>P. khinjuk</i>	3 spp., <i>P. atlantica</i> , <i>P. lentiscus</i> , <i>P. terebinthus</i>	One sp., <i>P. chinense</i>	ca. 10 spp., temperate Asia, Mediterranean region, South-east Asia, South USA, Mexico, and Guatemala

(Contd. from p. 7)

1.	2.	3.	4.	5.	6.
28.	<i>Berberis vulgaris</i>	nil	5 spp., <i>B. crataegina</i> , <i>B. cretica</i> , <i>B. integerrima</i> , <i>B. khorasanica</i> , <i>B. libanotica</i>	45 spp.	ca. 225 spp., north temperate zone particularly along the Andes and Himalayas
29.	<i>Elaeagnus angustifolia</i> L.	nil	one sp., <i>E. spinosa</i>	9 spp.	ca. 45 spp., chiefly in the north temperate and sub-tropical zone of old and New world
30.	<i>Diospyros lotus</i> L.	nil	one sp., <i>D. kaki</i>	45 spp.	ca. 200 spp., tropical and sub-tropical parts of the world
31.	<i>Cornus mas</i> L.	nil	one sp., <i>C. sanguinea</i>	4 spp., <i>C. cantroversa</i> , <i>C. capitata</i> , <i>C. macrophylla</i> , <i>C. stracheyi</i>	ca. 4 spp., central and southern Europe to Japan and Korea, and California
32.	<i>Crataegus azarolus</i> L.	nil	19 spp.	one sp., <i>C. oxyantha</i>	ca. 200 spp., north temperate region.

such as climatic differences, personal preferences, human habits, etc. Thirdly, several of the plants of the Middle East may have been introduced into south Asia from very ancient times as could be inferred from the prevalence of genetic differences. Few of them may have undergone considerable differentiation, and even further speciation in their new habitat in south Asia. And fourthly, some of the genera show wide distribution and variation in south Asian region. They may have differentiated into new species in south-west Asia. A few examples of each are discussed below.

The genus *Lactuca* (family Compositae), to which garden lettuce *Lactuca sativa* L. belongs, is a fairly large genus of *ca* 100 species occurring chiefly in the north temperate region of Eurasia and the Mediterranean region. Lettuce is one of the earliest known cultivated plants. It is believed to have originated in the warmer temperate regions of the Middle East from prickly lettuce, *L. serriola* L. The latter species occurs widely in central and south Europe, east Mediterranean, and west and central Europe. About 8-21 species of the genus are present in south-west Asia and south Asia, and atleast four species are common to both these regions. Further, two other species, *L. indica*, and to some extent *L. denticulata* are cultivated in east Asia.

The genus *Pyrus* L. (Rosaceae) includes *ca*.30 species. They are distributed widely in temperate Eurasia. The most common cultivated pear *P. communis* L. belongs to this genus. This species shows much polymorphism. Speciation is believed to have occurred in the genus in several areas of its occurrence, but more in temperate Europe, Caucasus, and east Asia. The genus *Prunus* L. (Rosaceae) is large and variable, containing *ca*. 140 species. It includes several edible stone fruits and seeds such as almond (*P. amygdalus* Batsch., now *Amygdalus communis* L.), peach (*P. persica* (L.) Batsch., now *Amygdalus persica* L.), plums (*P. domestica* L., *P. americana* Marsh., *P. salicina* Lindl., *P. spinosa* L., *P. cerasifera* Ehr.), apricot (*P. armeniaca* L.), and cherry (*P. avium* L., *P. fruticosa* Pall., *P. cerasus* L., *P. tomentosa* Thunb., *P. pumila* L., *P. bessyi* Bailey). A number of other species of this genus are used as ornamentals for their showy flowers. The genus is distributed widely in the north temperate regions. It shows several centres of variation such as east Asia, central Asia, Middle East and north America. It is represented by about three species in south-west Asia and 37 species in south Asia.

The genus *Zizyphus* Mill. (Rhamnaceae) includes *ca* 100 species. They are distributed widely in the tropics of Asia and America and the temperate regions of both the hemispheres. Vavilov (loc. cit.) listed south-west Asia as a secondary centre of *Z. sativa* Gaertn. (now, *Z. jujuba* Mill. non Lam.). Its centre of diversity has been suggested to be China. Two species have been recorded from south-west Asia and 13 species from south Asia. Thus, the genus shows greater variability in south Asia.

The genus *Vitis* L. (Vitaceae), which has ca 70 species, is distributed in the temperate to subtropical areas of Northern Hemisphere, but chiefly in America and east Asia. The delimitation of species in this genus has been very difficult, if not altogether artificial. Wild forms of *V. vinifera* L. occur in the Mediterranean region, spreading eastwards to Caucasus and northwards to central Europe. Ca 5 species occur in south-west Asia, four in south Asia, and none is common to both the centres. The regions of maximum diversity are central, middle, south-west and south-eastern Europe.

Berberis vulgaris L. (Berberidaceae), the European barberry, was used to be planted earlier for its edible berries, and subsequently as an ornamental. It is an alternate host of the stem rust of wheat, a serious disease of the crop, and hence, it is now being removed. The genus, containing ca. 225 species, is widely distributed in the north temperate zone and the Andean mountains. The species are extremely variable. Ca. five species occur in south-west Asia and 45 species in south Asia, mostly in the Himalayas. No species is common to both the regions.

The genus *Ficus* L. (Moraceae) is a large one containing ca. 850 species. They are distributed widely in the tropics and subtropics, but show greater abundance and distribution in south-west and south Asia, and Polynesia. The common cultivated fig, *F. carica* L. is considered to have originated in Carica in Asia Minor. Fig is cultivated widely in the tropics and subtropics, but chiefly in the Mediterranean countries and California (USA). Two *Ficus* spp., *F. bengalensis* and *F. religiosa* are held in esteem in south Asia by the Buddhists and Hindus. While ca 65 species have been recorded from south Asia, south-west Asia has only about five species. This genus shows great diversity in south and south-west Asia, but having the centre of origin of the most economically important species, the fig, in south-west Asia.

The pomegranate, *Punica granatum* L. (Punicaceae) is an ancient cultivated fruit of tropical and sub-tropical Asia. Presently, it is cultivated widely in the drier subtropics and temperate areas of the Mediterranean region, and south and central Asia. Wild forms of *P. granatum* occur widely from the Balkans to the sub-Himalayas of India. The only other species of the genus *Punica*, *P. protopunica* has been described from Socotra island in the Indian Ocean. The family Punicaceae is monogeneric and the genus *Punica* is dispecific, and yet, wild and cultivated forms of *P. granatum* occur widely in subtropical and temperate Asia and the Mediterranean region.

Origin of parsley, (*Petroselinum crispum* (Mill.) Nym. ex A.W. Hill) (Apiaceae), has been ascribed to this centre by Vavilov, but others (Simmonds, 1976; Zeven and de Wet, 1982) think that it originated elsewhere, in southern Europe. The species *P. crispum* does not appear to have any wild relatives in south-west Asia.

Eruca sativa L. (now *E. resicaria* (L.) Cav: Cruciferae) is another species (which Vavilov proposed) to have originated in south-west Asia, but other authors assume it to have originated elsewhere in Mediterranean region and south Asia. The quince, (*Cydonia oblong* Mill.) (Rosaceae), has been cultivated for a long time, but it does not have any wild relatives in either of these centres. Zeven and de wet (1982) have proposed it to have originated in south USSR.

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SYSTEMATIC RELATIONSHIPS AMONG SOME SPECIES OF *SOLANUM* L. SECT. *MELONGENA* L. – EVIDENCE FROM SEED CHARACTERS

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Solanum incanum L. and *S. insanum* L., two Indian wild and weedy forms of spinous Solanums, are closely related to *S. melongena*, the cultivated eggplant or brinjal. Evidence from light and scanning electron microscopy of the seed supports their close phylogenetic relationship. The three are nearly identical in the shape and size of the seed, the hilum and the seed epidermal cells. Seeds of "*S. melongena* var. *potangi*" on the other hand, have distinctly different morphology. This form of disputed taxonomic validity and uncertain identity is probably not available among the phylogenetically close relatives of eggplant.

Key words : *Solanum melongena*, *S. insanum*, *S. incanum*, "*S. melongena* var. *potangi*", seed, scanning electron microscopy, systematic relationships

Section *Melongena* L. of genus *Solanum* L. comprises six spinous species including *S. melongena*, the cultivated eggplant or brinjal. Eggplant is suggested to have originated in South Asia, probably India, where besides numerous cultivars, some wild and weedy forms known as *S. incanum* L. and *S. insanum* L. are also found. There is consensus that *S. incanum* is the progenitor of eggplant (Bhaduri, 1951; Narsimha Rao, 1979; Lester and Hasan, 1991). But disagreement exists regarding the relationships of *S. insanum*, this species has been regarded as either an ancestor or a weedy derivative of cultivars (Prain, 1903; Bhaduri, 1951; Lester and Hasan, 1991). Another plant, morphologically similar to eggplant and given the epithet "*S. melongena* var. *potangi*" (Mital, 1950), has been suggested as one of the progenitors of eggplant (Bhaduri, 1951). The identity of this form and the validity of its nomenclature have, however, been brought into question (Khan, 1979; D.B. Deb - Pers. comm.)

Several workers have used seed coat characters for the identification and taxonomic treatment of Solanaceae (Souèges, 1907; Wojciechowska, 1972; Gunn and Gaffney, 1974; Whalen, 1979; Lester and Durrands, 1984). Besides seed shape and colour, surface features like form and dimensions of epidermal

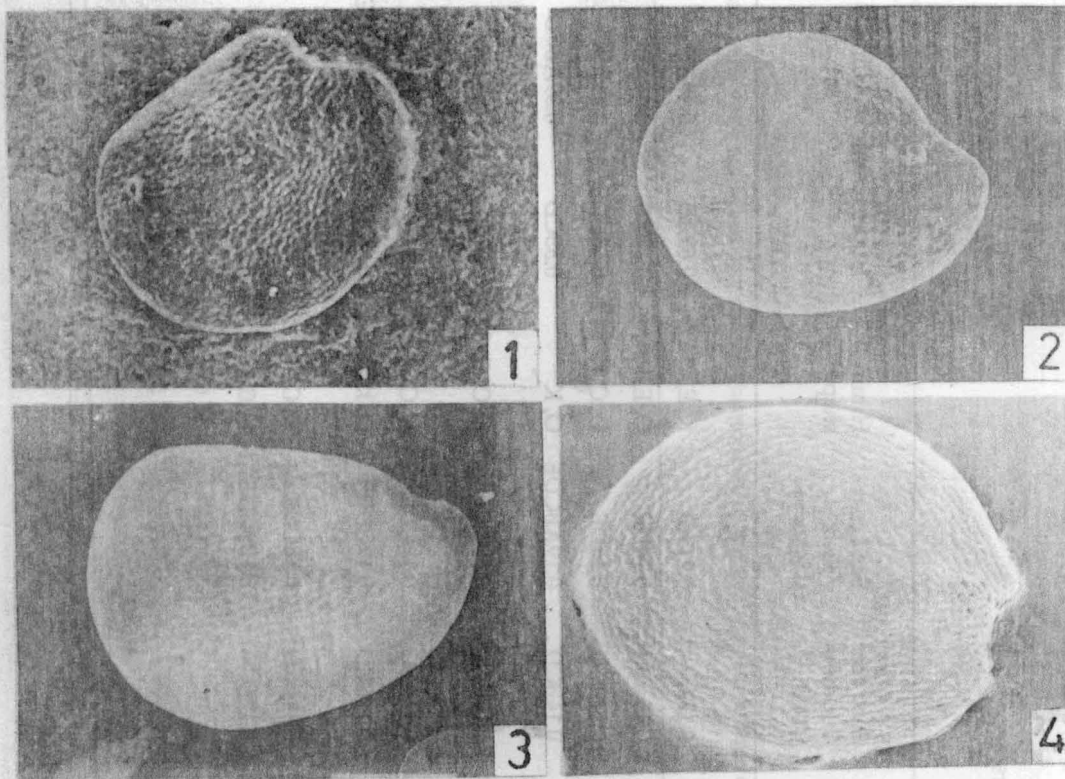
cells and patterns made by anticlinal wall thickenings have been used to differentiate numerous Solanaceous species. Earlier studies demonstrated the usefulness of seed surface microstructural features in resolving the systematic relationships of *S. melongena* and some related taxa (Karihaloo and Malik, 1992). In the present paper, detailed studies on the macro- and micromorphology of the seed and seed surface in several accessions of *S. melongena*, *S. insanum*, *S. insanum* and "*S. melongena* var. *potangi*" are reported.

MATERIALS AND METHODS

Seeds of nine cultivars (including named cultivars and landraces) of *Solanum melongena*, five accessions of *S. insanum* and one accession of *S. insanum* (Table 1), collected from different locations in India, were used for the present study. In addition, seeds from the original collection of "*S. melongena* var. *potangi*" (Mital, 1950) located in NBPGR were also investigated. Ten seeds of each accession were observed for their external morphology: overall seed shape and size (macromorphology) and shape and size of epidermal cells (micromorphology). The macromorphological features were studied under a dissecting stereomicroscope mounted with an ocular micrometer. Micromorphology of the seed epidermis was observed by scanning electron microscopy (SEM). Dry, untreated and enzyme treated seeds were used for the purpose. For enzyme treatment, the seeds were soaked in 1 per cent cellulase (Sigma c-7377) solution for 16 hr. Later, the seeds were thoroughly washed with distilled water and dried in an oven at 32°C for 18 hr. The seeds were mounted on brass stubs and coated uniformly with a thin gold layer in a JFC-1100 ion sputter. Scanning of the seed surface was done at an accelerated voltage of 25 KV by SEM model Jeol JSM 840 A. Measurements of cells and other components were made from enlarged photographs. Terminologies of Gunn and Gaffney (1974) and Barthlott (1981) were used for describing seed and seed surface structures. Statistical comparisons of the numerical data were made by Duncan's multiple range test (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The seeds of the presently investigated Solanums are light to dark-brown mostly C-shaped but also oblong and obovate (Table 1, Figs. 1-4). The hilum is marginal, key-hole shaped or rarely oblong, elliptical, linear and obovate. The seed length ranges between 2.31 mm and 3.61 mm, width between 2.03 mm and 3.15 mm and thickness between 0.76 mm and 0.94 mm. Hilum length among the accessions varies between 0.35 mm and 0.75 mm and breadth between 0.11 and 0.58 mm. Persual of Table 1 reveals that the average seed size of *S. melongena* is greater than that of the other three taxa. Since *S. melongena* has larger fruits than those of its putative progenitors, *S. insanum* and



Figs. 1-4. Scanning electron micrographs of the seeds of *Solanum melongena* (Fig. 1).
S. insanum (Fig. 2), *S. incanum* (Fig. 3) and "*S. melongena* var. *potangi*" (Fig. 4). $\times 14$.

S. incanum, it is probable that the genetic changes responsible for increasing the fruit size of the cultivars have also affected the size of their seeds. Table 1 also shows that there exist large and often significant differences in seed morphometry among the accessions in both *S. melongena* and *S. insanum*. Consequently, most characters show wide in ranges within species variations and these ranges overlap across species. Thus on the basis of the seed macromorphological characters, none of the investigated taxa can be distinguished as a distinct entity.

The morphometric details of the epidermal cells of the 16 investigated accessions are presented in Table 2. The epidermal cells are mostly isodiametric (Figs. 5-8), those towards the seed edges being tangentially elongated. The cell length ranges between 131.6 μm and 234.4 μm , and the cell breadth between 97.2 μm and 155.2 μm . The number of undulations varies between 7.4 and 15.0 per cell while the length of undulations ranges between 30.2 μm and 71.7 μm . As is evident from Table 2, overlapping ranges of variation in

Table 1. Seed characters of *Solanum* species and cultivars/accessions

Species and Cv./accession	Seed Outline shape*	Seed length (mm)	Seed breadth (mm)	Seed thickness (mm)	Seed coat thickness (mm)	Seed coat /seed thickness	Hilum shape**	Hilum length	Hilum breadth
<i>S. melongena</i>									
SM 85	C	3.36B	3.03AB	0.81C	0.17A	0.21AB	K, E, O	0.69AB	0.48AB
CA 172	C	3.61A	3.15A	0.94A	0.15ABC	0.16DE	O, E, K	0.67AB	0.44ABC
Arka Shirish	C	3.00C	2.50BE	0.88B	0.14BCD	0.16DE	O, C, K	0.53CDE	0.41ABC
West Coast Round	C	2.59DE	2.25GHI	0.74D	0.14BCD	0.19ABCD	O, K	0.55CD	0.39ABCD
Pusa Purple Cluster	C, O	3.36B	2.89BC	0.88B	0.14CD	0.16DE	K, O, E, C	0.75A	0.41AB
Manjari Gota	C	3.30B	2.80CD	0.88B	0.15ABC	0.17CDE	K, O	0.52CDE	0.30BCDE
Pusa Purple Round	C	3.01C	2.64DE	0.82C	0.14BCD	0.17CDE	O, K	0.66AB	0.38ABCD
IC-89823	C	2.90C	2.38FG	0.78CD	0.14BCD	0.18CDE	K, O	0.48DE	0.30BCDE
IC-89834	C	2.56DEF	2.28FHG	0.67E	0.12D	0.18BCDE	K, O	0.35F	0.22BCDE

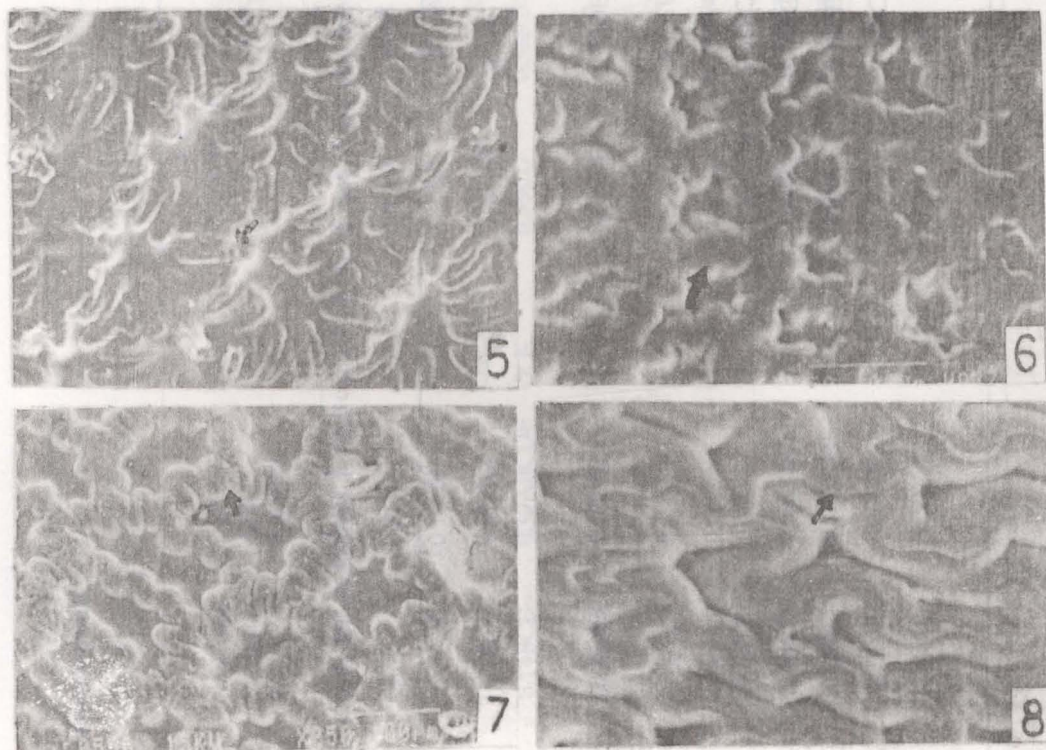
(Contd. from p. 15)

<i>S. insanum</i>										
JL-58	C, O	2.44EF	2.07IJ	0.88B	0.16AB	0.20ABC	K, O, E	0.51CDE	0.58A	
JL-62	C, O, Ob	2.31IF	2.03J	0.79CD	0.15ABC	0.19ABCD	K, O, L	0.47DE	0.20BCDE	
JL-39	C, O	2.36F	2.07IJ	0.68E	0.13CD	0.19BCDE	K, O	0.43EF	0.19CDE	
IC-3253	C, O	2.55DEF	2.05IJ	0.68E	0.13CD	0.19ABCD	K	0.44DEF	0.20BCDE	
IC-111404	C, O	2.79CD	2.36FG	0.73D	0.16AB	0.22A	K	0.52CDE	0.25BCDE	
<i>S. incanum</i>										
JL-64	C, O, Ob	2.75CD	2.14HIJ	0.75CD	0.15ABC	0.20AB	K	0.44DEF	0.14DE	
" <i>S. melongena</i> var. <i>potangi</i> "	C, O, Ob	2.84C	2.47EF	0.75CD	0.12D	0.16DE	L, O	0.61BC	0.11E	

*C : C-shaped; O: Oblong; Ob : Obvate

**K: Keyhole-shaped; E: elliptical; O: oblong; C: circular; L: linear

The different seed and hilum shapes of an accession have been arranged in order of their frequencies. In each column, figures followed by the same letter are not significantly different.



Figs. 5-8. Scanning electron micrographs of the seeds surface of *S. melongena* (Fig. 5), *S. insanum* (Fig. 6), *S. incanum* (Fig. 7) and "*S. melongena* var. *potangi*" (Fig. 8). Note the bead-like structure of cell margins in Figs. 5-7 and the thin line of depositions in Fig. 8 $\times 160$

the epidermal cell characters exist among *S. melongena*, *S. incanum* and *S. insanum*. "*S. melongena* var. *potangi*", however, stands out from these in having significantly fewer number of undulations per cell, shorter undulations and thinner cell margins than all the other taxa. Thus, the epidermal cell characters distinguish "*S. melongena* var. *potangi*" as a distinct form whereas the other three taxa are nearly identical with each other.

The appearance of the cell margins is another feature of taxonomic interest in the present materials. In all the accessions of *S. melongena*, *S. insanum* and *S. incanum*, the cell boundaries are dotted with bead-shaped structures (Figs. 5-7). Our earlier studies on single accessions of *S. melongena* and *S. insanum* had also revealed the bead-like appearance of cell boundaries (Karihaloo and Malik 1992). Identical structures in more accessions of these taxa indicate that

beading of the seed epidermal cell margins is a uniform character in these species. In "*S. melongena* var. *potangi*", the cell boundaries bear a structurally and chemically different kind of deposition. It is in the form of a thin raised line (Fig. 8) which unlike bead-shaped structures of the other taxa, is eroded by cellulase treatment.

Table 2. Seed epidermal cell characters of *Solanum* species and cultivars/accessions

Species and Cv./ accession	Cell length (µm)	Cell breadth (µm)	Number undulation/ cell	Length undulations (µm)	Cell margin thickness (µm)
<i>S. melongena</i>	108.3BC	140.6ABC	13.7AB	68.6A	14.5B
SM 85	178.4BC	154.2A	13.4ABC	71.4A	12.6B
CA 172	169.8CDE	138.8ABC	12.8ABC	47.2CDEF	7.6EF
Arka Shirish	169.8CDE	138.8ABC	12.8ABC	47.2CDEF	7.6EF
West Coast Round	188.0BC	142.8ABC	14.0AB	39.2FG	8.0DEF
Pusa Purple Cluster	171.2CDE	131.6ABCD	12.6ABC	55.6BC	13.8B
Manjari Cota	234.4A	140.2ABC	13.8AB	54.2BCD	14.8B
Pusa Purple Round	154.2EF	126.0CDE	15.0A	51.4CDE	8.8CDE
IC-89823	270.8D	155.2A	13.8AB	52.0CDE	15.4B
IC-89834	168.0CDE	126.6CDE	11.2CD	48.2CDEF	13.8B
<i>S. insanum</i>					
JL-58	159.0CDE	97.2F	13.0ABC	41.8EF	12.2BC
JL-62	131.6F	108.4DEF	13.4ABC	45.0DEF	11.6BCD
JL-39	163.8CDE	120.9CDE	12.9ABC	52.3CDE	14.6B
IC-3253	157.2DEF	128.6BCDE	11.2CD	60.6AB	15.4B
IC-111404	184.4BCD	153.0AB	10.2D	46.6CDEF	20.2A
<i>S. incanum</i>					
JL-64	177.0CDE	105.5BEF	10.2D	48.6CDEF	12.8B
" <i>S. melongena</i> var. <i>potangi</i> "	185.8BCD	108.4DEF	7.4E	30.2C	5.0F

In each column, figures followed by the same letter are not significantly different.

The above detailed close similarity in the seed characters of *S. melongena*, *S. incanum*, and *S. insanum* points to the close phylogenetic relationship existing among them. Previous crossability studies have led to similar conclusions (Narsimha Rao, 1979); consequently these species have been treated as closely interrelated forms of a larger group, *S. melongena* complex (Lester and Hasan, 1991). Several taxonomists have treated *S. insanum* as a variety of *S. melongena* while Deb (1989) merged both the taxa under *S. incanum*.

The shape and size of seed epidermal cells of "*S. melongena* var. *potangi*", on the other hand, establish this taxon as a form quite distinct from the *S. melongena* complex. Thus the present studies do not support the contention of Bhaduri (1951) that "*S. melongena* var. *potangi*" is a progenitor of *S. melongena*. As mentioned in the introduction, the validity of the nomenclature "*S. melongena* var. *potangi*" is disputed (Khan, 1979; Karihaloo and Malik, 1992). Further, there seems to be no reference material, except nongerminable seeds, available for the verification of its identity and relationships. In view of these facts, it seems doubtful whether as one of "*S. melongena* var. *potangi*" should be given any serious consideration.

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AUGMENTATION AND UTILIZATION OF COFFEE GERMPLASM IN INDIA

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Exploitation of indigenous and exotic coffee germplasm in India is reviewed. The thrust areas of breeding research and the basis of evolution of selections utilizing the rust resistant genes and genes conferring agronomic traits such as plant type, yield and quality is described. A brief outline of future strategy to exploit the heterosis of F_1 hybrids is also presented.

Key words : *Coffea arabica* L., breeding, selection, rust resistant genes

Coffea arabica L. is the only tetraploid species of the genus with the chromosome number $2n=2x=44$. It is also the most important species in coffee trade since 17th century. While coffee was believed to have been introduced into India in the early 17th century, its commercial exploitation began in the early 19th century with the British entrepreneurs establishing plantations (Smith, 1985). The earliest coffee cultivar grown in India was known as Chiks. Leaf rust disease of arabica coffee caused by *Hemileia vastatrix* B et Br. appeared in India on an epidemic scale in the late 19th century (Coffee Board, 1985). Enterprising planters tried to produce arabica cultures with resistance such as Coorg and Kents from the Old Chiks. Besides this, efforts were also made to introduce disease hardy species like *Coffea liberica* and *C. canephora* (Robusta) (Vishveshwara, 1974). When all these endeavours failed to produce plant materials with stable resistance and quality yield, the need for an organised research programme was felt, paving the way for the establishment of the Central Coffee Research Institute (CCRI) in 1925 (then known as Mysore Coffee Experiment Station).

The success of any breeding programme depends on the proper evaluation and judicious utilization of the available genetic resources. The plant breeding group of CCRI started collecting the various coffee types in an effort to establish a germplasm bank. Between 1925 and 1940, different coffee types from the various states in India were collected and exploited to increase coffee

productivity (Sreenivasan and Ramaiah, 1988). Early coffee selections (Sin. 1, Sin. 2 and Sin. 3) emanated from these collections.

Exotic germplasm

After 1940, arabica germplasm from various exotic sources was added to the gene bank at CCRI. The exotic germplasm contributed a great deal to the evolution of coffee selections in India as explained below.

Thrust areas

Soon it was realized that S26 (putative hybrid of *C. arabica* and *C. liberica*)- and descendant selections (Sin.1, Sin.2 and Sin.3) tend to produce considerable quantities of deformed/malformed beans collectively termed Triage (Narasimhaswamy *et al.*, 1961; Narasimhaswamy and Vishveshwara, 1962). Thus, the efforts were directed to evolve arabica types with resistance and quality with particular emphasis on eliminating triage and increasing A grade beans in the produce (Vishveshwara, 1971, 1974; Srinivasan and Vishveshwara, 1980; Sreenivasan, 1991). Cup quality traits like body and acidity are evaluated by the Quality Control Division of Coffee Board. Adaptability of the evolved types is being tested in the Coffee Demonstration Farms and Regional Coffee Research Stations located in various agro-climatic zones (Reddy *et al.*, 1986). In other words, breeding for resistance, quality, adaptability and improved productivity became the main thrust areas of research at CCRI. Genes from exotic germplasm were generously utilized in achieving the above objectives.

Rust resistance genes

While there are approximately 360 surviving collections of *C. arabica*, the promising ones are Agaro, Cioccie (J-type), Geisha (C-type) S₁₂ Kaffa (I-type) and Tafari-kela (HR) from Ethiopia, Bourbon and San Ramon (E-type) from Guatemala and Hibrido-de-Timor (HDT) (A Type) and Catimor (complex of A and R types) from Portugal. These materials primarily served as the sources of major genes (S_H genes) conferring resistance to leaf rust. The genes S_H 4 and S_H 5 of Agaro and Cioccie, S_H 1 and S_H 4 of S₁₂ Kaffa, S_H 1 and S_H 5 of Geisha, S_H 6, 7, 8, 9 of HDT were targeted to be incorporated into the locally adopted cultures S288 and/or S795. S288 and S795 manifest G (S_H 3 & S_H 5) and H (S_H 2, 3, 5) types of rust reaction respectively. Thus, the present day arabica populations in India comprise an assemblage of S_H 1 to S_H 9 factors in a wide array of combinations conferring variable degrees of resistance to the leaf rust disease (Table 1).

Horizontal resistance observed in Rume Sudan (S881) and Tafari-kela collections was also exploited, primarily to evolve plant type combining vertical and horizontal resistance (Sreenivasan *et al.* 1993).

Table 1. Impact of germplasm introductions on Arabica coffee production

S.No.	Year	Germplasm	Genes exploited	Cultivars	Yield (kg/ha)	% Increase of yield	
1.	1940	S.26 (S.288) Kents	C-type S _H 3, 5 D-type S _H 2, 5	Typica (T) Typica (T)	Sin.3	225.00	
2.	1960	Hibrido-de-Timor(HDT)	A-type S _H 6, 7, 8, 9	Typica(T)	Sin.8	450.00	100.00
3.	1970	Agaro	J-type S _H 4, 5	Typica(T)			
		Cioccie	J-type S _H 4, 5	Typica(T)			
		Geisha	C-type S _H 1, 5	Typica(T)	Sin.4	580.00	157.78
		S ₁₂ Kaffa	I-type S _H 1, 4	Typica (T)			
		Tafarikela	HR	Typica(T)			
		San Ramon	E-type S _H 5	Dwarf (Sr)	Sin.7	600.00	166.67
4.	1975	Tafarikela	HR	Typica (T)			
		HDT	A-type	Typica (T)	Sin. 90	630.00	180.00
		Caturra	E-type	Semi-dwarf(Ct)			
		Cioccie	J-type	Typica (T)	Sin. 10	650.00	188.89
		S.795	H-type S _H 2, 3, 5	Typica(T)			
5.	1985	Caturra	E-type	Typica (T)	Catimor/	775.00	244.44

Genes conferring agronomic trait

Plant type : Concomittant with improving the disease resistance, characters conferring compactness and dwarf nature were also exploited leading to the evolution of dwarf (San Ramon) and semi dwarf (Caturra) plant types. The genes Sr (San Ramon) and Ct (Caturra) are dominant and facilitated quick increase of the frequency of dwarf and semi-dwarf types in the descendant progenies of appropriate parentage. As original San Ramon and Caturra are both highly susceptible to leaf rust (E-type, S_H 5), the resistance factors were introduced into these types through hybridization with S 795, Cioccie/Agaro, Geisha and HDT.

Thus, San Ramon was crossed with S 795 to introduce resistance to races I and II of *H. vastatrix* (Sin. 7.1) and with Cioccie/Agaro to impart resistance to race VIII (Sin. 7.2) and finally with HDT to incorporate maximum possible resistance (Sin. 7.3). Caturra was involved in a double cross [(Caturra × S. 795) × (Caturra × S₆ Cioccie)] to impart resistance to races I, II and VIII (Sin.

10) and Catimor/Cauvery is a descendant of Caturra $\times$ HDT. Selection was exercised in the progenies for a combination of resistance and plant type. However, the present day dwarf and semi-dwarf coffee populations of the sub-continent present an assemblage of variable resistance which needs critical assessment.

Yield : Considering the release of S 795 (Sln. 9) as a landmark event in the improvement of coffee yield in India, the present day production patterns reflect a vast advancement of this particular character (Fig. 1, Table 2). Ad-

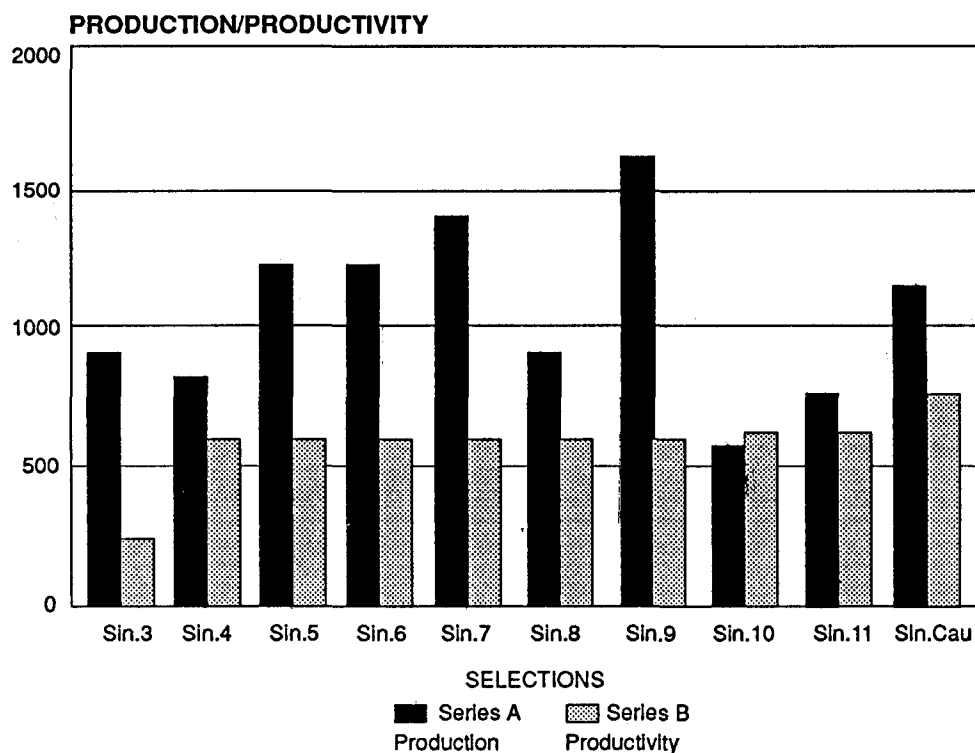


Fig. 1. Production and productivity of various coffee selections

mittedly, this is a result of the adoption of a good package of practices (sometimes grower innovations) superimposed on the improved materials with a high degree of resistance and production potential.

Quality : Improvement of quality was primarily through reducing triage and increasing large bean grades in the produce (Sreenivasan, 1991). Ethiopian landraces Agaro and Cioccie are known to produce bold beans and are utilized

in the breeding programmes to evolve plant types producing quality coffee (Coffee Board, 1985).

The Future

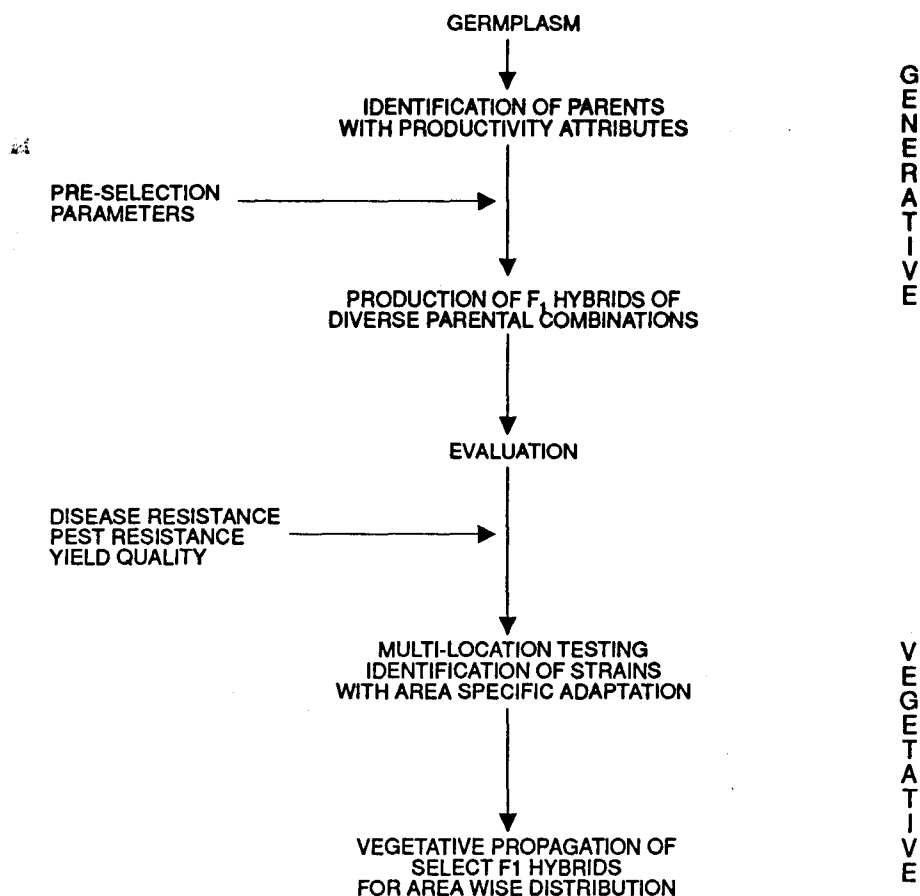
The exploitation of F_1 hybrids of coffee for vigour, resistance and yield was considered as the best strategy in increasing coffee production atleast since the early 1980's and efforts were made to evolve techniques for the production of F_1 hybrid seed of *C. arabica* (Van der Vossen and Walyaro, 1981; Ram and Ramaiah, 1991; Agawanda, 1993). The F_1 hybrids of Ethiopian landraces Geisha, Tafari-kela and S_{12} Kaffa and other arabicas and HDT are known to be superior in yield, resistance and growth characters (Sreenivasan and Ram, 1992). A good strategy for exploiting them should combine generative and vegetative selection methods (Scheme 1) as follows:

- i) The generative component : Pre-testing the F_1 hybrids of various parental combinations to understand the combining ability and heterosis patterns (Bayetta-Bellachew *et al.*, 1993).
- ii) The vegetative component : Propagating the superior F_1 hybrids through vegetative means on a mass scale.

This method is advantageous on account of the large genetic base of the hybrids conferred by the generative selection and requisite residual genetic variation (required for adaptability) among the vegetative descendants. In an effort to further exploit the available germplasm, identification of gene sources to obtain resistance against pests and environmental adversaries and their utilization in breeding is contemplated with the objective of producing varieties amenable for organic farming. Another approach which may be followed by the breeders is the adequate understanding of pre-selection parameters (Walyaro and Van der Vossen, 1979; Srinivasan, 1982) and their possible use in parent selection (Scheme 1).

In conclusion, the considerable increase in coffee productivity in India can be mainly attributed to the utilization of exotic germplasm in the breeding programmes and evolution of newer selections (Sin. 4, 5, 7, 8, 9, 10 and Cauvery) as the recommended package of practices remained essentially the same over the period 1940-1990 (Coffee Board, 1987). Efforts are now in progress to evolve Double Cross and Multi-Parent hybrids to further improve coffee productivity in India.

SCHEME 1 FUTURE STRATEGIES OF GERMPLASM UTILIZATION IN COFFEE



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LOW PHOSPHORUS TOLERANT CULTURES IN UPLAND PADDY GERMPLASM AND THEIR UTILIZATION

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Four hundred and fifty germplasms collected from North-eastern Hill region were screened in phosphorus deficient soil for identification of tolerance to low phosphorus condition. Some of the promising lines (65) were evaluated again in hydroponics and a few tolerant lines (26) were further utilised in breeding programme. With these approaches tolerant varieties were identified from germplasm resources. While utilising a few elite lines in a systematic breeding programme undertaken for such stress condition, a few cultures (15) were developed which can be grown in different agro-ecological condition as biological amendment to boost up the productivity in problem soils.

Key words : Paddy germplasm, low phosphorus tolerant, utilization

Thousands of hectares of upland rice growing soils are acidic in nature. It is one of the major problems in upland and distributed universally (Garrity 1984). Acidic pH coupled with high amount of Fe and Al causes P-deficiency. The low pH in acidic soil limits the P-uptake for plants in unavailable form. In artificial phosphorus application, it gets fixed in the acidic soil in the presence of Al and Fe. Soil amendment is very costly as well as not a permanent solution. On the other hand, breeding for tolerance to low P-conditions is a practical solution (IRRI, 1975, 1976, 1978, 1979). Variation for tolerance/susceptibility has been reported earlier. An attempt was made to screen a few lines collected from predominantly red lateritic acid soil with low phosphorus condition of North eastern hill region of India. (Asthana and Majumder, 1981).

MATERIALS AND METHODS

Soil status: The experimental site for field screening of P-tolerant cultures, had red lateritic soils, pH 5.0 (soil : water, 1 : 2.5) available p-5ppm, organic matter 6.4 per cent exchangeable aluminium 0.25 meq/g, exchangeable iron-

45ppm., poor in available phosphorus status. The site is in upland terrace without water stagnation.

EXPERIMENT I : Four hundred and fifty rice germplasms collected from N.E. Hill areas, were screened in upland terrace, in the soil mentioned above. Seeds were drilled 5 cm apart in 2m row width, replicated two times in with and without phosphatic fertilizer (60 and 0 kg/ha P) application. Rasi, a low P-tolerant variety was taken as biological check. Observations were taken on height, days to flowering, ear bearing tillers (EBT), yield per plot and phenotypic index following IRRI standard evaluation system. P-uptake was measured in leaf samples collected at flowering stage (Yoshida *et al.*, 1976) and microchemical test for P-status in root was assessed taking a transverse cross section of root stained in a solution of ammonium molybdate in nitric acid. Grading for phosphores was done on the basis of intensity of yellow colour developed.

EXPERIMENT II : Sixty five varieties screened from initial screening trial in the P- deficient soil were included for hydroponic screening. Seeds were kept in the oven at 50°C for 5 days to avoid seed dormancy. Surface sterilisation of seeds was done by dipping in formaldehyde solution (16 ml/l) for 15 min. Seeds a soaking for sterilisation was followed by an incubation period for 43 hrs. Well germinated seeds (10 seeds / variety / replication) were placed in the styrofoam sheet to float on nutrient solution (Yoshida *et al.*, 1976). Culture solution was modified slightly for two treatments of P-availability 0.5 and 10 ppm. The critical pH 6.5 was maintained for P-availability with an adjustment daily with alkali or acid. Three seedlings/variety/replication were taken for screening and inserted in the Styrofoam sheet keeping in contact with the culture solution. Culture solution was changed as mentioned above. Records were taken at 30 days of plant growth for different plant characters such as plant height, tiller number, leaf area, root volume, shoot and root dry matter. Tolerance index was measured as $P_1 P_2 \times 100$, where P_1 and P_2 are values at 0.5 and 10 ppm respectively. Statistical analysis was done in accordance with Gomez and Gomez (1976).

EXPERIMENT III : A few tolerant lines identified so far were crossed with high yielding IRRI varieties (IR 28, IR 29 and IR 30), DR 92 and Rasi, tolerant to low P-condition. Seventy lines developed (fixed) for such condition were evaluated in a trial conducted in the upland conditions with and without phosphatic fertilizer application (@ 0 and 60kg/ha phosphorus), alongwith a local (Ngoba) and improved (Rasi) biological check.

RESULTS AND DISCUSSION

EXPERIMENT I : Among the varieties (450) tested, 14 varieties were found to be quite tolerant to low phosphorus condition (Table 1). Excepting

Table 1. Performance of promising traditional rice germplasms in P- deficient soil

Culture	Height		Tolerance index		Days to flowering		EBT		Tolerance Index		Yield/plot(g)		Tolerance index		P-up take ppm		PI	MCT
	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀		
Khaonowjoma	113	127	39	154	152	152	2.8	3.4	82	82	481	1256	38.8	38.8	6.8	6.8	3	M
Konoldhan	95	118	81	155	152	152	2.7	4.3	63	63	154	220	70.0	70.0	5.8	5.8	3	M
Maibiring	116	123	94	146	143	143	2.8	3.2	88	88	420	1416	29.7	29.7	6.9	6.9	3	M
Rasangtu	110	113	97	151	149	149	3.1	4.7	66	66	299	708	42.2	42.2	4.2	4.2	5	L
Khawji	114	120	95	155	153	153	2.5	3.1	81	81	437	1257	38.7	38.7	8.2	8.2	3	H
Emo Empo	120	180	92	153	151	151	2.7	3.1	87	87	470	1635	28.7	28.7	7.3	7.3	3	H
Millock 2	127	137	93	151	149	149	2.9	3.3	88	88	821	1451	56.6	56.6	5.6	5.6	3	M
Tura 80	113	127	89	153	151	151	3.1	4.8	65	65	248	1431	17.3	17.3	3.4	3.4	7	L
Khawant	115	139	83	154	154	154	2.1	4.1	51	51	459	1306	55.1	55.1	5.6	5.6	3	M
Chuksingpa	117	131	89	150	148	148	2.7	3.7	73	73	452	1613	28.0	28.0	6.6	6.6	3	H
IC 25692	108	130	83	153	151	151	1.8	2.9	62	62	450	1116	40.3	40.3	4.8	4.8	5	M
Ngoba	66	101	65	128	114	114	3.1	4.1	76	76	372	360	43.3	43.3	8.4	8.4	3	H
Asienkel	118	135	37	152	149	149	3.2	4.7	68	68	453	1163	39.0	39.0	9.6	9.6	3	H
IC 25696	124	135	92	149	147	147	2.6	3.8	68	68	467	1597	29.2	29.2	6.3	6.3	3	H
Rasi (Control)	60	81	74	97	97	97	2.2	3.2	69	69	370	880	42.0	42.0	7.3	7.3	3	H

PI - phenotypic index

MCT - Microchemical test (colour intensity, high - H, medium - M, Low - L).

Tolerance index = $\frac{P_0 \text{ yield}}{P_{60} \text{ yield}} \times 10$ Plot size = 5m²

varieties, Khonoldhan and Rasangtu, others were better yielder than control (Rasi) where phosphorus was withdrawn. Hillock 2 was the best followed by Khawji, Khaonowjama, Emo Empo, IC 25696, Khawsant, Asenkel, Chuksingpa and IC 25692. But when the individual varieties were compared with and without phosphorus Konoldhan and Hillock No.2 were found to be quite tolerant. In respect of P-up take ability Asienkel, Ngoba, Khowji and Emo Empo were found to be very efficient. Also the micro chemical test, taking a transverse section of culm staining with ammonium molybdate in nitric acid was found to be very reliable for screening the variety to P-tolerance. Kasangtu, Khawji, Maibiring, Hillock No. 2, Emo Empo and IC 25696 had maximum tolerance in respect of height when compared with and without p- level. Regarding EBT, Hillock No.2, Maibiring, Emo Empo, Khawnowjoma and Khawji showed enough tolerance.

Tolerance to low phosphorus condition might be due to efficient uptake and utilization of phosphorus (Majumder *et al.*, 1990 a, b, c). Good phenotypic index covering plant type and pest resistance indicated their profitable use as such or utilization in breeding programme. Micro chemical test at flowering stage is assumed to be a quick and reliable test for screening varieties. These varieties were collected mainly from upland hill areas and their tolerance could be due to homeostatic effect.

EXPERIMENT II : On the basis of performance of a large number varieties tested initially in p-deficient soil, 65 varieties were picked up and tested in hydroponics in two p-level, 0.5 ppm (deficient) and 10 ppm (normal) respectively. Twenty six varieties enlisted in table 2 were found performing better in P-deficient condition. In respect of tolerance index calculated, Pyat pyani, Khatu, IC 25736 and Changhoepal for plant height; Keturn, Changhoepal, IC 25639, IC 25736, EC 25721, Kerpu and Mirikrak for tiller number; Ketura, Changoepal, Changsan, Pyat pyani, Khaokha okenon, Tura 680, IC 25696, IC 25687 and Changat for root volume; pyat pyani, ARC 7098, Changsan and Changoepal for shoot dry matter and pyat pyani, Khatu, IC 25736, Chuksingpa, IC 25721 and Mirikrak were found to be very promising.

Due to P-deficiency, leaf area was affected maximum followed by shoot dry matter, root volume, root dry matter, leaf number and plant height (Fig.1) among the characters studied. Higher coefficients of variation in some characters viz., indicates the scope of selection of some desirable types from the lot. Significant positive correlations were found (Table 3) between leaf area vs. tiller number, root volume, shoot dry matter and root dry matter; root volume vs. plant height, leaf area, shoot dry matter and root dry matter; shoot dry matter vs. plant height and root dry matter and root dry matter vs. plant height. This shows further, scope of indirect selection.

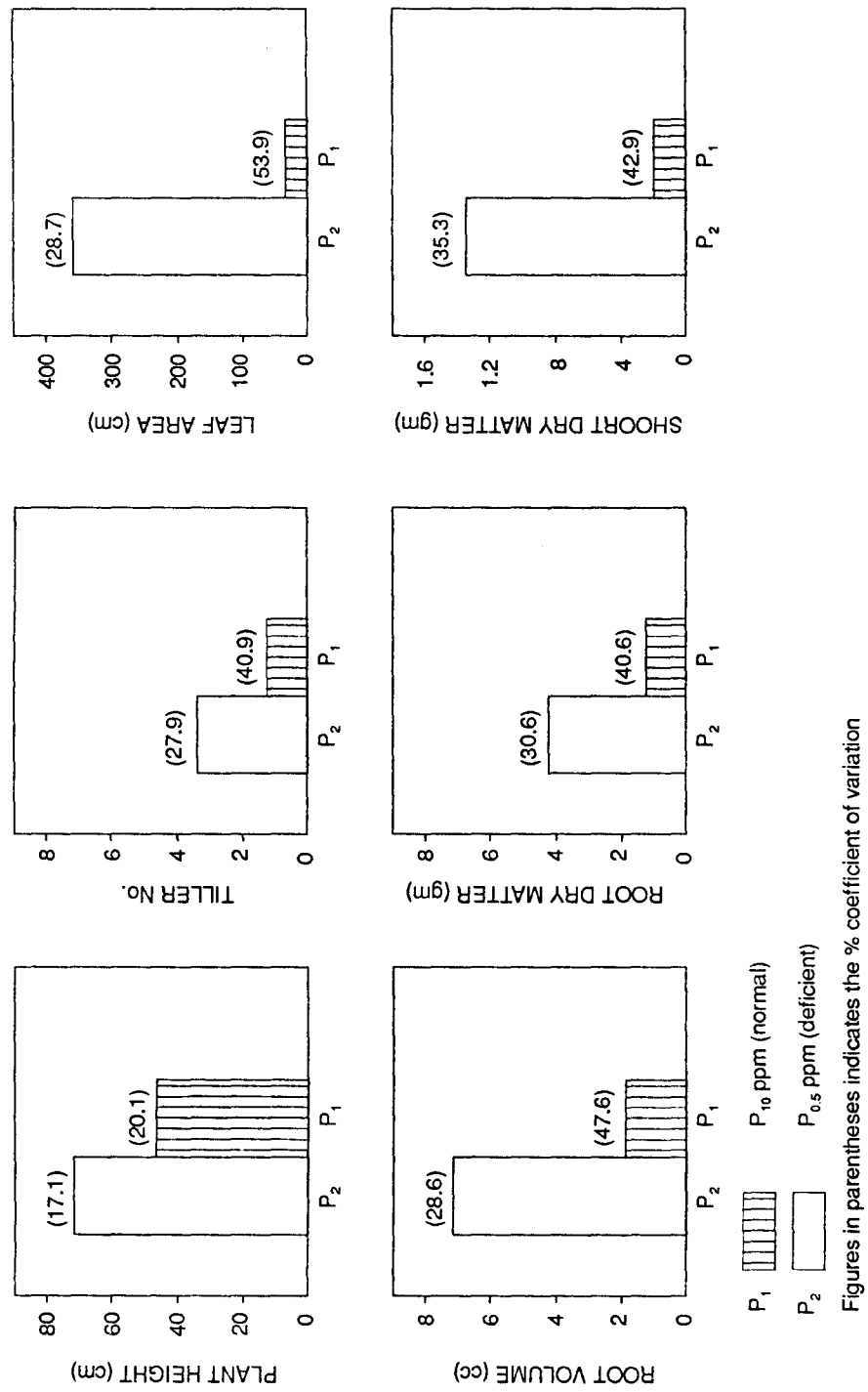


Fig. 1. Performance of traditional varieties in different phosphorus level (P₁₀ ppm-normal)

Table 2. Performance of promising rice germplasms in hydroponics

Germplasm	Plant height (cm)		Tiller number		Leaf area cm ²		Root volume cc		Dry matter									
									Shoot (g)			Root (g)						
	T ₁	T ₂	T ₁	T ₂	T ₁	T ₂	T ₁	T ₂	T ₁	T ₂	T ₁	T ₂	T ₁	T ₂	T ₁	T ₂		
ARC 7098	39.2	72.5	43	1	3	33	17.3	270.6	6	1.2	6.1	20	0.33	0.94	35	0.08	0.28	29
Changsan	44.9	70.7	64	1	3	33	49.3	245.9	20	2.3	7.1	32	0.25	0.83	30	0.10	0.35	29
Changhoepal	49.5	67.5	73	3	5	60	101.7	470.3	22	2.4	7.8	31	0.36	1.22	30	0.13	0.33	39
Changat	45.8	88.7	52	1	3	33	28.3	391.4	7	2.0	5.0	40	0.18	1.56	12	0.07	0.35	20
Chuksingpa	48.5	80.5	60	1	3	33	39.2	320.0	12	2.2	6.4	34	0.23	1.13	20	0.16	0.39	41
IC 25637	43.6	73.9	59	1	3	33	29.1	412.0	7	3.0	7.6	40	0.21	1.55	14	0.07	0.39	18
IC 25689	44.2	70.0	63	1	2	50	26.7	233.8	11	2.9	8.2	35	0.18	1.14	16	0.07	0.29	24
IC 25694	44.3	69.0	65	1	3	33	26.7	343.7	8	1.3	13.0	10	0.12	1.73	7	0.07	0.50	14
IC 25696	47.2	78.8	60	1	3	33	21.5	303.9	7	2.0	5.0	40	0.19	1.09	17	0.11	0.35	31
IC 25736	46.0	62.6	74	1	2	50	28.0	183.2	15	1.9	5.2	37	0.23	1.12	21	0.14	0.27	52
IC 25721	34.9	58.0	60	1	2	50	19.3	131.2	15	1.2	4.4	27	0.13	0.57	23	0.08	0.20	40
Ketura	24.4	38.1	64	3	3	100	49.6	97.6	50	1.3	6.6	20	0.26	1.15	23	0.11	0.34	32
Khatu	47.0	62.0	76	1	3	33	26.7	323.7	8	1.2	6.1	20	0.32	1.19	27	0.12	0.23	52

(Contd. from p. 36)

Kerpu	37.0	59.7	62	1	2	50	22.3	155.9	14	1.7	7.8	22	0.15	0.71	21	0.07	0.27	26
Khaokha0-kenon	37.0	79.7	49	1	3	33	22.1	137.0	6	3.2	5.5	58	0.21	1.43	15	0.11	0.36	31
Local Ahu-A	49.1	71.8	68	1	3	33	31.2	394.2	13	1.6	7.3	22	0.36	1.65	22	0.14	0.41	34
Mirikrak	45.3	94.7	48	1	2	50	41.8	355.7	12	1.9	8.5	22	0.32	1.36	24	0.16	0.40	40
Mesong	46.7	69.0	68	1	3	38	26.6	254.5	11	0.9	5.8	16	0.20	1.01	20	0.95	0.25	32
Maikutsuk	34.1	70.2	49	1	4	25	22.2	390.0	6	1.1	5.6	20	0.28	1.25	22	0.08	0.67	12
Napgai	41.0	85.3	48	1	4	25	23.4	529.5	4	0.6	5.1	12	0.14	1.96	7	0.04	0.27	15
Pyatpyare	45.0	72.7	62	1	4	25	27.5	336	7	8	2.0	6.2	32	0.27	1.25	20	0.07	0.36
Pyatpyani	65.0	80.3	81	1	3	33	41.2	252.2	16	4.5	5.4	83	0.33	0.84	39	0.20	0.30	67
Phanlem	51.3	80.0	64	1	4	25	31.1	438.3	7	2.0	8.4	24	0.37	1.53	24	0.17	0.46	37
Ryllored-5	50.1	80.3	62	1	4	25	22.5	406.2	6	2.1	5.4	39	0.29	1.52	18	0.09	0.42	21
Tura 115	54.8	88.0	62	1	4	25	46.2	475.9	10	2.5	7.4	34	0.32	1.52	21	0.11	0.35	31
Tura 690	47.2	73.0	65	1	3	33	34.8	368.6	9	3.2	7.5	43	0.27	1.62	17	0.14	0.46	30

(T₁ and T₂, phosphorus treatment at 0.5 and 10 ppm respectively).

Table 4. Performance of breeding lines in P-deficient soil

Culture	Parentage	Days to flowering		Height		EBT		Yield/plot (g)		Tolerance index	PI score (0-9)
		P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀	P ₀	P ₆₀		
RCPU 101	(IR 28/Ngoba)/Ngoba	113	105	113	116	3.3	4.4	576	634	91	1
RCPU 103	(IR 28/Ngoba)/Ngoba	109	105	70	74	2.8	3.3	481	596	91	5
RCPU 105	(IR 28/Ngoba)/Ngoba	99	96	66	68	3.0	3.8	414	807	51	3
RCPU 107	IR 30 × Ngoba	100	92	111	114	4.4	5.0	403	618	65	5
RCPU 108	IR 30 × Ngoba	108	103	96	89	6.0	6.2	330	945	35	3
RCPU 109	IR 30 × Ngoba	110	103	87	89	5.8	6.1	840	878	96	1
RCPU 110	IR 30 × Ngoba	99	96	69	74	4.2	4.8	429	639	68	3
RCPU 111	IR 30 × Ngoba	118	111	62	68	4.4	4.5	368	960	38	5
RCPU 121	IR 29 × Ngoba	109	103	66	69	4.4	4.6	387	490	79	5
RCPU 123	IR 29 × Ngoba	109	102	81	94	3.4	4.6	567	600	94	1
RCPU 127	IR 29 × Mirikrak	108	103	78	81	3.9	5.0	352	370	95	5
RCPU 128	IR 29 × Mirikrak	104	99	66	69	3.2	4.9	357	439	81	3
RCPU 130	Mirikrak × Rasi	101	98	73	76	3.2	3.4	386	565	68	3
RCPU 131	(DR 92 × Mirikrak)	108	106	64	68	3.4	3.6	330	340	97	5
RCPU 132	(DR 92 × Ngoba)	108	99	68	73	3.2	3.6	434	600	72	3
Ngoba (Local check)	× Ngoba	122	119	36	39	4.8	5.2	405	700	58	1
Rasi (Improved check)	× Ngoba	104	101	66	70	5.0	5.7	335	570	59	3

PI - Phenotypic index, Tolerance index (TI) = $\frac{P \text{ yield}}{60P \text{ yield}} \times 100$, Plot size 2.5 sqm.

Table 3. Estimation of correlation coefficients among plant characters under different p-level

	Plant height	Tiller No.	Leaf area	Root volume	Shoot volume
Tiller number	-0.238 (-0.231)				
Leaf area	0.333** (0.497)**	0.721** (0.517)**			
Root volume	0.552 ** (0.269)*	0.088 (0.180)	0.446* (0.415)*		
Shoot dry matter	0.596** (0.512)**	0.296* (0.235)	0.694** (0.608)**	0.562**] (0.528)**	
Root dry matter	0.579** (0.394)**	0.103 (0.254)*	0.516** (0.559)**	0.676** (0.568)**	0.751** (0.634)**

Figures in parenthesis are p (10 ppm) and others P (0.5ppm).

* and **, significant at 5% and 1% respectively.

EXPERIMENT III : IR 28, IR 29, IR 30, and Rasi were identified as phosphorus tolerant varieties. Some of the elite and P-tolerant lines were crossed with IR 28, IR 29 and IR 30. Segregants in advancing generations (F_2 - F_6) were screened in P-deficient soil as mentioned earlier. Some of the materials fixed and found to be tolerant to low phosphorus. Materials in RCPU series, so obtained were given for yield trial in two treatments (phosphorus level 0 and 60), replicated three lines. Among the lines (70) tested, fifteen lines were found to be quite promising (Table 4). RCPU 131 had maximum tolerance followed by RCPU 109, RCPU 127, RCPU 123, RCPU 101, RCPU 128 and RCPU 103. These cultures showed good phenotypic index (PI) and significantly better yielder than both Rasi (improved check) and Ngoba (local check). Some of the promising germplasms were utilised in these breeding programmes and lines derived from the cross involving either Ngoba and Mirikrak as one of the parents were found to be promising. These elite lines can be used as biological amendment to increase the productivity in such problem soils.

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SCREENING RICE GERMPLASM FROM NORTH EAST HILL REGION FOR TOLERANCE TO ALUMINIUM TOXICITY

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Aluminium toxicity is one of the most important factor among the edaphic stresses in the chemical environment in upland, lateritic soils. This study, helped in identification of 27 traditional varieties (15 from laboratory study and other 12 in phytotron study) tolerant to Al toxicity. The magnitude of affect due to Al was also recorded in different traits. These tolerant germplasm would be useful as such or in the breeding programme as donor parents.

Key words : Rice, germplasm, tolerance, Al. toxicity

In presence of heavy aluminium (Al) in the soil, phosphorus, even if present in sufficient quantity, becomes unavailable to the plant. Moreover Al impairs the intake of other essential ions and water by the plant (Foy, 1974). The toxicity due to Al is found in most of the crops growing in upland soil. One such area with problem soils in N.E. Hill region is also, a reservoir of large number of traditional varieties which, because of growing over the years, are likely to be adapted over such conditions. Hence, enough to search for a tolerant material in this germplasm, a screening programme was undertaken.

MATERIALS AND METHODS

A collection of 200 traditional varieties from Northeastern Hill region (Asthana and Majumder 1981) was screened for Al-toxicity in hydroponic condition. Seeds were kept in the oven at 50°C for 5 days to avoid seed dormancy. Seed surface sterilisation was done by formaldehyde solution (16 ml/l) for 15 min. Seeds were soaked, followed by incubation for 48 hours. Well germinated seeds (10 seeds/ variety/ treatment/replication) were placed in the styrofoam sheet to float on nutrient solution (Yoshida, 1976) with and without Al, viz., two treatments - 0 and 30 ppm Aluminium (in the form of

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$\text{AlCl}_3 \cdot 6\text{H}_2\text{O}$). A critical pH 4.0 was maintained, adjusting daily with alkali or acid in the nutrient solution to ensure Al availability to the plants. Biological checks (tolerant cultures - MW 10, Karyangya Gora etc.) were used to compare with varieties whose reaction were not known as well as for their screening. Culture solution was renewed after seven days. At fifteen days, observations were taken for shoot and root length, root volume, dry matter of shoot and root. Tolerance index was computed as $(\text{Al}_{30}/\text{Al}_0) \times 100$, where Al_0 and Al_{30} are magnitudes at 0 and 30 ppm respectively. The length of root deposit with Al was measured by haematoxylin staining technique which was adapted for routine screening of the varieties. Seedling grown in 30 ppm Al were transferred to water for 1 hr. followed by staining with haematoxylin, later on they were transferred in tray and covered with moistened paper. Observations were taken on staining due to Al diffusion in root portion as complete, partial and no staining.

In another experiment, 80 varieties were included in this screening programme. Seed treatment for breaking dormancy, surface sterilisation, incubation, placement in styrofoam sheet, treatments and after care in the experiment were similar as followed in the previous experiment. This experiment was conducted in phytotron, at IRRI (29/21°C, day and night temperature; 90% RH). Observations were taken on four characters as mentioned earlier excepting haematoxylin staining technique followed in earlier case.

RESULTS AND DISCUSSIONS

Out of the 200 traditional varieties from hilly areas of northeastern India screened in hydroponic conditions, 15 varieties were found to be most tolerant and 11 varieties were most susceptible (Table 1). The characters root length and total root mass were reported to be adversely affected by toxic Al concentration. Among the tolerant varieties Ngoba, Jorang, Changkohpal, IC 25688, IC 25727, Chamic, IC 25729, Hate Black Hull, Kohheng, IC 25697, and IC 25698 were found to be excellent as evident by minimum reduction of root growth and dry matter (score 1-5). In these varieties, Al diffusion was found to be absent or in other words Al ions were restricted at root tip or could not enter in the root, but IC 25697 and IC 25698 were the exceptions where Al diffusion was partial. So, latter two varieties escape somehow by any physiological means without much adverse effect. The varietal screening in hydroponic conditions was earlier advocated by Howeler and Cadavid (1976) and Tanaka and Navasero (1966) in rice.

On the contrary susceptible varieties had very poor root growth and dry matter turn over (score 7-9). Haematoxylin stain is bound with Al ions in the root and this showed the extent of Al deposit in the root (Marinez, 1976). Aluminium diffusion was recorded as mostly complete excepting a few remain

Table 1. Salient features of selected rice germplasm from N.E. Hill region for Aluminium tolerance

Accession Number	Culture	Place of collection	Tolerance index		Aluminium diffusion
			Root length	Dry-matter	
Most tolerant					+
2	Ngoba	Meghalaya	5	3	NS
198	Jorang	Arunachal Pradesh	5	1	NS
298	Changkohpal	Manipur	3	1	NS
128	IC 25688	Arunachal Pradesh	3	1	NS
167	IC 25727	Arunachal Pradesh	3	3	NS
94	Chamic	Arunachal Pradesh	1	1	NS
169	IC 25729	Arunachal Pradesh	5	1	NS
279	Eyroya (B)	Manipur	5	3	PS
276	Hate black hull	Manipur	1	3	NS
255	Kohheng	Manipur	5	1	NS
137	IC 25697	Arunachal Pradesh	3	3	PS
223	Boro	Arunachal Pradesh	5	3	PS
138	IC 25698	Arunachal Pradesh	1	5	PS
267	Kohn	Manipur	5	3	PS
259	Bangmai	Manipur	5	3	PS
Most Susceptible					+
81	Nemo (A)	Arunachal Pradesh	7	9	CS
65	Tura 299	Meghalaya	7	9	CS
217	Maidang Ahu	Arunachal Pradesh	7	9	CS
119	Champhal	Arunachal Pradesh	7	9	CS
140	IC 25700 (A)	Arunachal Pradesh	7	9	CS
108	Pangra Balongba	Arunachal Pradesh	9	9	CS
341	Yaribatsuk (A)	Nagaland	9	7	PS
266	Napdai Hangmeh	Manipur	7	9	CS
10	Nonglwai	Meghalaya	7	9	CS
40	Tura 212	Meghalaya	9	7	PS
198	Daro	Arunachal Pradesh	9	7	CS

NS = No staining, C = complete staining, P = Partial staining.

ing as partial. Such an extent of Al deposited in the root zone effected the intake of water and other essential ions or their free upward movement for physiological processes (Foy, 1974). Aluminium as such is not toxic to the plant but, it arrests the movement of useful ions for the plant, ultimately causes a poor growth of the plant. Besides a few most tolerant and susceptible varieties others were found to be intermediate type.

Table 2. Response of rice varieties to Aluminium toxicity

Character	Treatment	Parameter	
		Range	Mean
Shoot length	T ₀	20.1 - 45.4	34.97
	T ₃₀	18.6 - 44.1	33.25
Root length	T ₀	9.5 - 20.6	14.61
	T ₃₀	4.5 - 16.6	9.31
Tolerance index	-	29.2 - 95.3	63.24
Shoot length: Root length	T ₀	1.57 - 3.85	2.47
	T ₃₀	2.08 - 6.81	3.85
Shoot dry matter (A)	T ₀	0.33 - 0.72	0.53
	T ₃₀	0.25 - 0.70	0.45
Root dry matter (B)	T ₀	0.11 - 0.32	0.22
	T ₃₀	0.10 - 0.22	0.14
A : B	T ₀	1.97 - 3.08	2.42
	T ₃₀	2.09 - 5.02	3.33

T₀, T₃₀ - Al treatment, 0 and 30 ppm respectively. Tolerance index $(T_{30}/T_0) \times 100$.

The significant difference in varietal means, particularly in root characters (Table 2) between the treatments (0 and 30 ppm) confirmed the effect of aluminium. The deleterious effect of toxic Al concentration was found to act on plant growth. However, phenotypic coefficients of variation (PCV) and genotypic coefficients of variation (GCV) (Table 3) varied in the array of varieties and higher magnitude of coefficients of variation was recorded for various characters which in turn, provided a scope to select tolerant genotypes. The varietal resistance to problem soils was earlier suggested by (Ponnamperuma, 1975) in rice. Among the characters studied root length, root and

shoot dry matter were highly affected and the plant height showed least effects. Negligible reduction was noticed in plant height (4.1 %) whereas tiller number, shoot dry matter and root dry matter reduced by 36.3, 15.1 and 36.4 per cent respectively (Fig. 1). The shoot-root ratio was found to decrease by 55.9 per cent might be due to the injury specially in the root parts which in turn affected the proportion of dry matter in those organs with a magnitude of 37.6 per cent. The variances due to treatment and varieties were found to be significant (Table 3) and thus confirmed the effect of Al on plant growth. However, the diversity in the varieties gives an opportunity to select the tolerant lines which was aimed at. Among the varieties studied Ate local, Thlan-chhuah, Chao, Nikhunkati, IC 25736, IC 25721, Farmbuh, Changatpal, Mirikrak, Pyatpyani, Kohn and Changsan were found to be quite tolerant as compared to the susceptible varieties like changpalman, Napdai, Hangmeh, Mesong, kati, IC 25704 and Ryllored 5.

Table 3. Analysis of variance

Source	DF	Characters			
		Shoot length	Root length	Shoot dry matter	Root dry matter
Replications (R)	1	9.59	0.14	0.0018	0.0057**
Al-treatment (T)	1	239.09**	2234.38**	0.3535**	0.4841**
Variety (V)	79	101.90**	27.30**	0.0336**	0.0039*
T x V	79	6.34	4.64	0.0059	0.0015
P C V		21.0	27.4	26.5	23.6
G C V		19.8	23.0	22.2	15.7

*, ** significant at 5% and 1% respectively

The estimation of correlation coefficients (Table 4) in those characters studied showed the associationship of shoot length vs. root length and shoot

Table 4. Estimation of correlation coefficients

Character		Shoot length	Root dry matter	Shoot dry matter
Root length	T ₀	0.979**	0.972**	0.962**
	T ₃₀	0.961**	0.280*	0.270*
Shoot dry matter	T ₀	0.983**	0.993**	
	T ₃₀	0.972*	0.944**	

*, ** Significant at 5% and 1% respectively

T₀ - Al, 0 ppm

T₃₀ - Al, 30 ppm

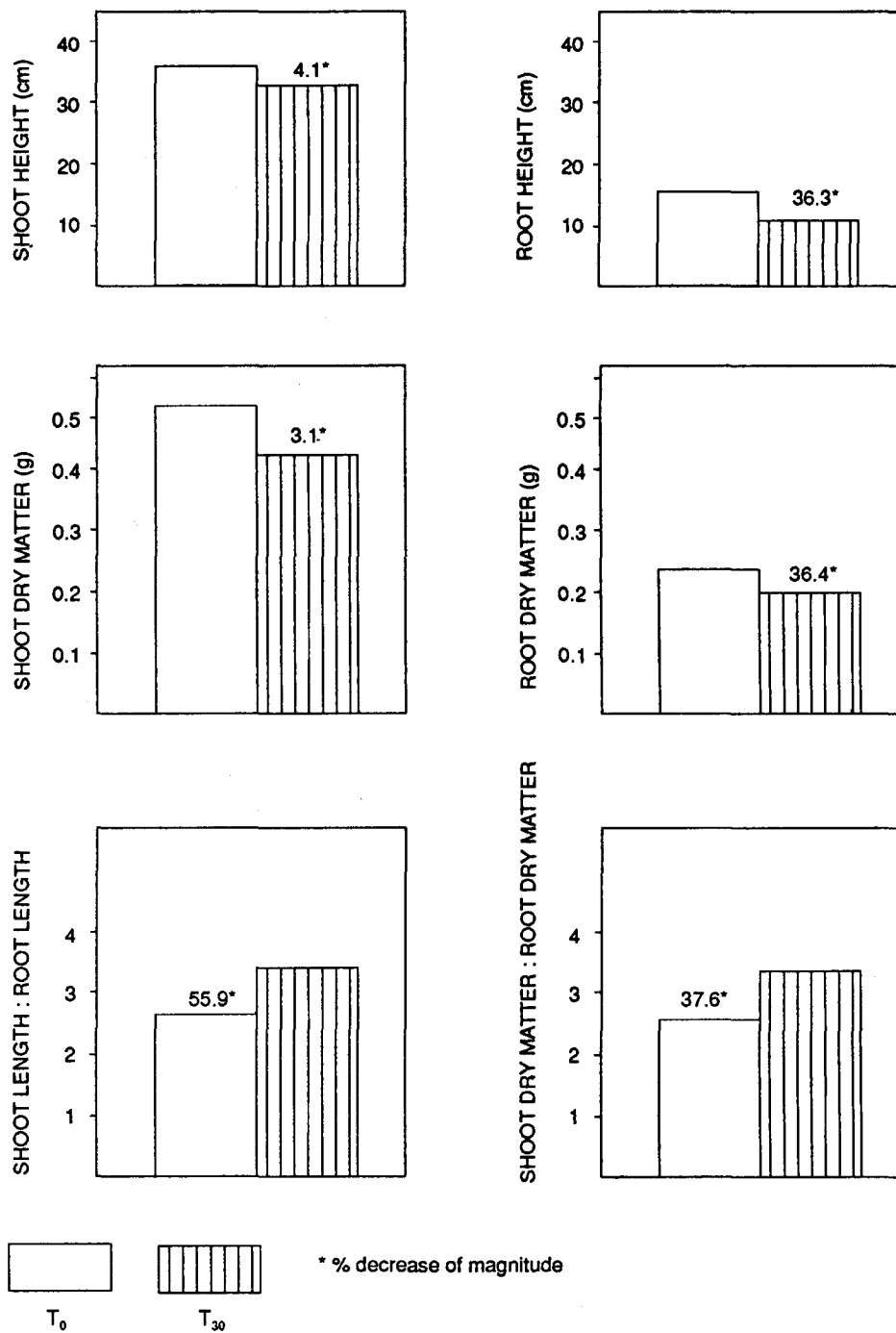


Fig. 1. Effect of Al concentration on morphological characters in rice (T_0 , T_{30} - Al, 0 and 30 ppm respectively)

dry matter and root dry matter vs. shoot dry matter. Unlikely, correlation between root length vs. root dry matter and shoot dry matter varies considerably under different growth conditions mentioned above. This estimation makes an opportunity for indirect selection as well as judicious selection method. The correlation coefficients of root length vs. root dry matter and root length vs. shoot dry matter when compared in both the cases viz. T_0 (without Al ions) and T_{30} (with toxic Al ions), it was found that in the latter cases the magnitude is much lower than that found in without Aluminium treatments. This observation indicated that in toxic Al concentration both the characters were not proportionately affected unlike the other three correlation coefficients.

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EVALUATION OF SOME RICE GENOTYPES FOR RESISTANCE TO BACTERIAL BLIGHT, *XANTHOMONAS* *ORYZAE* PV *ORYZAE*

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Rice germplasm comprising some Indian and exotic cultivars, donors for 'bacterial blight resistance' in the Indian rice breeding programme and some scented primitive rice cultivars, were evaluated for reaction to five genetically characterized isolates of *Xanthomonas oryzae* pv. *oryzae*. All these cultivars could be classified into 13 diverse groups on the basis of their reaction spectra. BR 285-5-6-6-2, IET 8320, IET 8326, IET 8584, IET 9691, IET 10745, IET 11005, IET 12188, IR 32720-139- 2-1-1-2, PERH 2 and PR 110 were resistant to all the five isolates. Out of the scented/basmati type landraces of rice, Xiang Geng Dao was resistant to all the five isolates; eight others namely Karnal Local, Basmati 1, Basmati 372, Basmati 376, Basmati 397 Basmati C-622, Basmati 5888 and Basmati Sufaid were resistant to only two weekly virulent isolates. Resistance to bacterial blight for the scented/basmati type rices should be sought in landraces or transferred from non-scented rices.

Key words: Rice, bacterial blight resistance, *Xanthomonas oryzae* pv *oryzae*, resistance

Resistance against bacterial blight caused by different pathotypes of *Xanthomonas oryzae* pv. *oryzae* Ishiyama sp. Nov. nom. rev. in rice (*Oryza sativa* L.) prevalent in India has been identified from time to time. Screening against single uncharacterized pathotypes/ isolates of the bacterium has a limited practical utility (Rao *et al.* 1971). Therefore, five single colony isolates of *oryzae* were characterized for their reaction to rice lines with known genes for resistance (*Xa* genes) to bacterial blight. Rice germplasm comprising some Indian and exotic rice cultivars, promising lines in the Indian rice breeding programme and some scented primitive rice cultivars were evaluated for resistance to these isolates.

MATERIAL AND METHODS

Five single colony isolates of *X. oryzae* pv. *oryzae* maintained in the Department of Genetics, Punjab Agricultural University, Ludhiana were char-

acterized in terms of their avirulence/ virulence formulae (effective/ineffective resistance genes) on differential lines carrying known genes (Xa genes) for resistance to bacterial blight. Eight rice lines in the background of IR 24 obtained from International Rice Research Institute, Manila, Philippines namely, IR-BB-3, IR-BB-4, IR-BB-5, IR-BB-7, IR-BB-8, IR-BB-10, and IR-BB-11 carrying *Xa3*, *Xa4*, *Xa5*, *Xa7*, *Xa8*, *Xa10* and *Xa11* genes, respectively, for resistance to bacterial blight and rice cv. *Tetep* carrying *Xa2+Xa16* were used as differentials while susceptible rice cv. Taichung Native 1 (TN 1) was included as check.

For determining its avirulence/virulence formula, aqueous suspension (10^9 cfu/ml) of 48 hr old growth of a bacterial isolate multiplied on potato sugar peptone Agar (2:1:1:2) medium at 25°C was inoculated on 70 day old plants grown in pots in greenhouse following clipping technique of Kauffman *et al.* (1973). Twenty randomly selected leaves from five different plants were scored for their reaction to bacterial blight on 1-9 scale (IRRI, 1988 a,b), 14 days after inoculation. An isolate showing resistant (R) or moderately resistant (MR) reaction (mean score 1.0-5.4) on a particular differential line was designated as "avirulent" while that showing moderately susceptible (MS) to susceptible (S) reaction (mean score more than 5.4) was designated as "virulent".

The isolates of the bacterium thus characterized were inoculated, using the methods already described, on 70 day old plants (in maximum tillering to boot stage) of different rice lines raised in field during 1991. Rice germplasm evaluated here included 54 genotypes comprising Indian and exotic cultivars, donors for 'bacterial blight resistance' in the Indian rice breeding programme and some elite scented rice lines. Twenty randomly selected leaves from five different plants in each host genotype-pathogen isolate combination were scored for the disease reaction, 14 DAI both in 1991 and 1992. Rice lines with an overall mean leaf blight score upto 5.4 were classified as resistant (R) (IRRI, 1988 a,b) while those with higher scores (1-9 scale) as susceptible (S).

RESULTS AND DISCUSSION

The reaction of five isolates of *X. oryzae* pv. *oryzae* on eight differential rice lines with known sources of resistance (Table 1) revealed that isolate G-1 was avirulent on *Xa4*, *xa5* and *xa8* but virulent on *Xa2+Xa16*, *Xa3*, *Xa7*, *Xa10* and *Xa11*. Isolate G-2 was avirulent on all the *Xa* genes tested except *Xa2+Xa16*. Isolate G-3 showed avirulent reaction on all the *Xa* genes, however, G4 was avirulent only on *Xa4* and *xa8*. Isolate G-5 was avirulent on *Xa4*, *xa5*, *Xa7* and *xa8* but virulent on *Xa2+Xa16*, *Xa3*, *Xa10* and *Xa*. Thus all these isolates constituted five different pathotypes. On the basis of similarities and differences in the overall reaction spectrum of five isolates during the two years, the rice germplasm screened here could be classified into 13 diverse groups (Table 2).

Table 1. Reaction of different isolates of *Xanthomonas oryzae* pv. *oryzae* on rice lines with known sources of resistance (differentials) to bacterial blight and their avirulence/virulence formulae

Isolate	Reaction to rice lines*									**Avirulence/virulence
	Tetep	IRBB -3	IRBB -4	IRBB -5	IRBB -7	IRBB -8	IRBB -10	IRBB -11	TN1	
G-1	S	S	MR	MR	S	R	S	S	S	<i>Xa4, xa5, xa8, Xa2 + Xa16, Xa3, Xa7, Xa10, Sa11</i>
G-2	S	R	R	R	R	R	MR	MR	S	<i>Xa3, Xa4, xa5, Xa7, xa8, Xa10, Xa11/Xa2+ Xa16</i>
G-3	R	R	R	R	R	R	R	R	S	<i>Xa2 + Xa16, Xa3, Xa4, xa5, Xa7, xa8, Xa10, Xa11</i>
G-4	S	S	MR	MS	S	MR	S	S	S	<i>Xa4, xa8, Xa2 + Xa16, Xa3, xa5, Xa7, Xa10, Xa11</i>
G-5	S	S	R	R	R	R	S	S	S	<i>Xa4, xa5, Xa7, xa8, /Xa2 + Xa16, Xa3, Xa10, Sa11</i>

*Reaction score (on 1-9 scale of S.E.S. of rice, Anon. 1988) R = Score 1-3.4, MR = 3.5-5.4, MS = 5.5-6.4, S = 6.5-9

**Avirulence = MR/R reaction, Virulence = MS/S reaction

Thirteen genotypes namely BR 285-5-6-6-2, IET 8320, IET 8326, IET 8584, IET 9691, IET 10745, IET 11005, IET 12188, IR 32720-139-2-1-1- 2, PERH-2, PR 109, PR 110 and a scented rice land race, Xiang Geng Dao were resistant to all the five isolates of *X. oryzae* pv. *oryzae* tested. Likewise, BR 51-50-3-4, IET 10844, IET 11047, IET 11130, IET 11394, IET 11394, IET 12174, IET 12869, IR 58, IR 64, IR 29341-85-3-1-3, IR33355-39-1-1-3, IR58028-3-3-13, PERH-1 and PERH-1 and PERH-3 had resistant reaction to four isolates. Commercial rice cultivars like HKR 120, Jaya, PR106 and Pusa 44-33 were resistant to three isolates. BR 285-5-6-6-2 and IET 8584 (RP 2151-173-1-8) are known to be resistant to bacterial blight at 33 locations across Asia and also have a good phenotypic acceptability (IRRI, 1988a). Similarly, IET 10844, IET 11047, IET 12188 and IET 12869 were reported to be resistant to the leaf blight phase and IET 11130 and IET 12174 to both leaf blight and *kresek* phase of this disease at more than 10 locations in India (AICRIP, 1990, 1991).

Table 2. Classification of different rice genotypes on the basis of their spectrum of resistance to five isolates of *Xanthomonas oryzae* pv. *oryzae*

Group	Reaction* to isolate					Cultivars / lines
	G-1	G-2	G-3	G-4	G-5	
1	R	R	R	R	R	ER 285-5-6-62, IET 8320, IET 8326, IET 8584, IET 9691, IET 10745, IET 11005, IET 12188, IR 32720-138-2-1-1-2, PERH 2, PR109, PR110, Xiand Geng Dao
2	S	R	R	R	R	IET 12174, IET 12869, IR 5828-3-B, PERH 1 and PERH 3.
3	R	S	R	R	R	IET 11394
4	R	R	R	S	R	IET 11130
5	R	R	R	R	S	BR 51-50-3, IET 10844, IET 11047, IR 29341-85-3-1-3, IP 33355-39-1-1-3, IR 58, IR 64
6	R	R	R	S	S	IR 34, IR 36, IR 46
7	R	R	S	R	S	C 731067
8	S	R	R	R	S	HKR 120
9	S	R	R	S	R	BR 319-1-HR-28, Jaya, Pusa 44-43, PR 106
10	S	S	R	R	R	IET 12175
11	S	R	R	S	S	IR8, IR54, IR56, PAU1126, PR108, Karnal Local, Basmati 1, Basmati 372, Basmati 376, Basmati 397, Basmati C-622, Basmati 5888, Basmati Surfaid 100
12	S	S	R	S	S	Sakthi
13	S	S	S	S	S	Pak Basmati 385, Pusa Basmati 1, TN1

*R = Resistant, S = Susceptible

It is significant that scented/basmati type rice lines, Karnal Local, Basmati 1, Basmati 372, Basmati 376, Basmati 397, Basmati C622, Basmati 5888 and Basmati sufaid were resistant (Table 2) to only two isolates whereas commercial scented cultivars Pak Basmati 385 and Pusa Basmati 1 were susceptible to all the isolates of *X. oryzae* pv. *oryzae* tested here. Since scented/basmati type rice has a vast potential for export, resistance to bacterial blight for this type of rice should either be sought in more of its landraces or transferred from non-scented rice. The grouping of different rice lines as done here can serve as a basis for postulating probable genotypes of the members of each group for reaction to bacterial blight. The rice lines in diverse groups can be crossed for upgrading level of resistance to this disease for use in rice improvement programme.

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VARIABILITY PATTERN IN PSYLLIUM

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Phenotypic and genotypic coefficient of variability, heritability in broad sense and genetic advance as percentage of mean were studied for ten quantitative characters in 39 genotypes of isabgol (*Plantago ovata* Forsk.). Number of spikes per plant and biological yield had high estimates of genotypic coefficient of variation, heritability and genetic advance as percentage of mean, which suggests that direct selection for these traits would be fruitful in the improvement of this crop. Heritability estimates was highest in 1000 seed weight and lowest in spike length.

Key words : Psyllium, *Plantago ovata*, variability, heritability, genetic advance

Psyllium popularly known as isabgol (*Plantago ovata* Forsk.) is an important cash crop of western Rajasthan and northern Gujarat has a great commercial and medicinal importance due to its thin, rosy white, light membranous coating on the seed. Most of the *isabgol* is exported which bring in sizeable foreign exchange annually. India continues to hold monopoly in the production and trade of *isabgol* in the world. Isabgol offers better prospects for intensive cultivation in arid-sandy to sandy-loam type of soil. It is non-exhaustive crop having low fertility requirement (Kalyanasundaram *et al.*, 1982). Despite its importance, there is lack of research efforts on the improvement of this crop. Kalyanasundram and Dalal (1981) reported association between seed yield and some of the component traits. In the present study, attempt was made to investigate the genetic variability, genetic advance (as percentage of mean) and heritability of seed yield and its component traits.

MATERIALS AND METHODS

The experiment was laid out in randomized block design with 39 entries, replicated 3 times at Mandor (Jodhpur), during *rabi* season 1993-94. Each plot consisted of 4m long rows with a spacing of 30cm between rows and 10 cm between plants. Ten plants of each entry in each replication were used for recording data on days to flowering, days to maturity, plant height, of tillers per plant, spikes per plant, spike length, 1000 seed weight, biological

yield, harvest index and seed yield. Mean values of each genotype were used for statistical analysis. Genotypic and phenotypic coefficient of variation (Burton, 1951), heritability in broad sense (Johnson *et al.*, 1953) and genetic advance (Lush, 1949) were estimated.

RESULTS AND DISCUSSION

Characterwise estimates of genotypic and phenotypic coefficient of variation, heritability in broad sense and genetic advance as percentage of mean are presented in Table 1. The PCVs were observed to be invariably higher

Table 1. Estimate of genetic parameters for 10 characters in isabgol

Character	Range	Mean $\pm$ SEm	Genotypic variance	Phenotypic variance	GCV (%)	PCV (%)	Heritability (%)	GA	GA as % of mean.
Seed yield/plot (kg)	0.86-14.6	1.16 $\pm$ 0.07	0.02	0.03	12.33	16.66	53.96	0.21	18.53
Days to flowering	60-69	63.51 $\pm$ 0.74	4.32	5.90	3.27	3.82	73.22	3.66	5.76
Days to maturity	108-117	112.30 $\pm$ 0.74	5.00	6.67	1.99	2.30	75.88	3.98	3.59
Plant height (cm)	27.46 - 39.06	33.38 $\pm$ 1.10	9.44	13.09	9.20	10.83	72.11	5.37	16.10
No.of tillers/plant	4.26-7.93	5.55 $\pm$ 0.40	0.66	1.15	14.64	19.36	57.31	1.26	22.86
No.of spikes/plant	27.80-55.20	40.25 $\pm$ 0.95	54.40	57.16	18.32	18.78	95.17	14.82	36.83
Spike length (cm)	17.26 - 23.53	20.43 $\pm$ 0.92	1.38	3.97	5.76	9.75	34.86	1.42	7.00
1000 Seed weight (g)	1.37-2.14	1.72 $\pm$ 0.01 $\pm$ 0.01	0.03	0.03	11.11	11.16	95.55	0.39	22.75
Biological yield /plot (kg)	2.50 - 4.81	3.94 $\pm$ 1.08	39.90	43.41	16.00	16.69	91.91	6.05	31.66
Harvest index (%)	18.26 - 34.72	23.61 $\pm$ 0.93	11.52	14.13	14.75	16.33	81.54	6.31	27.43

than the corresponding GCVs for all the characters studied. The number of spikes per plant exhibited maximum genetic variation (18.32%) followed by biological yield (16.0%) and harvest index (14.75%), whereas seed yield per plot exhibited moderate genotypic coefficient of variation (12.33%), suggested that the selection for these traits would be much effective. Swarup and Chaugale

(1962) suggested that GCV alone is not sufficient for determination of the amount of heritable variation, which can be found out with greater accuracy when heritability in conjunction with genetic advance is studied. The percentage of heritability was highest for 1000 seed weight (95.55%). This high magnitude revealed that the trait influence very less by the environmental fluctuation. Such character could be improved directly through selection. The character like spike length showed least heritability (34.86) explained suggesting highly susceptibility to the environmental changes. Johnson *et al.* (1955) suggested that heritability and genetic advance when calculated together are more useful for predicting the resultant effect of selecting the best individual than heritability or genetic advance alone. High heritability estimates coupled with high genetic advance as percentage of mean were noticed in number of spikes/plant and biological yield. But 1000 seed weight showed high heritability and moderate genetic advance as percentage of mean. Such values of high heritability and genetic advance may be attributed to the action of additive genes (Panse, 1957). Kalyanasundram and Dalal (1981) reported that no. of spikes per plant, biological yield and 1000 seed weight are the important component traits of seed yield and hence selection for these characters would be more fruitful in future breeding improvement programme.

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VARIATION AND CHARACTER ASSOCIATION STUDIES IN CLUSTERBEAN (*CYAMOPSIS TETRAGONOLOBA* (L.) TAUB.)

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Analysis of variance for ten quantitative characters in 81 genotypes of clusterbean showed significant variability for all the traits. Branches plant⁻¹, pods plant⁻¹, pods cluster⁻¹ and seed yield plant⁻¹ had high genotypic coefficient of variability, high heritability and high genetic advance (% of mean). Seed yield per plant showed significant and positive correlation with pods per plant, clusters per plant and pods per cluster at genotypic and phenotypic levels, while it had significant and positive phenotypic association with plant height and branches per plant. Both genotypic and phenotypic correlations of pods plant⁻¹ with clusters plant⁻¹ and pods cluster⁻¹ were significant and positive.

Key words : Clusterbean, *Cyamopsis tetragonoloba*, analysis of variance

Clusterbean (*Cyamopsis tetragonoloba* (L.) Taub.) locally known as guar is an important *kharif* season, drought tolerant leguminous crop, particularly of arid and semi-arid areas of north-western Indian desert. It is grown for seed, fodder and as a vegetable crop either pure or in mixture. Guar seed contains gum or mucilage, mannogalactan, which is used in various industrial products. Variability in the population, especially for the characters where improvement is sought for, is important for successful crop improvement programme, whereas, character association will help in simultaneous selection of two or more characters at a time. Therefore, the present investigations were undertaken to study variation and character association in clusterbean.

MATERIALS AND METHODS

Eighty-one genotypes of clusterbean were grown in Randomized Block Design with three replications at Agricultural Research Station, Mandor, Rajasthan, during *kharif* season of 1993 under rainfed situations. Each plot consisted of two rows, 3 m long and 45 cm apart. Plant to plant distance was maintained at 15 cm. Observations were recorded on 5 randomly selected competitive

plants in each plot and data were collected on 10 attributes viz., days to flowering, days to maturity, plant height (cm), branches plant⁻¹, seeds pod⁻¹, 1000-seed weight (g) and seed yield plant⁻¹ (g).

Mean data were subjected to statistical analysis. Genotypic (V_g) and phenotypic (V_{ph}) variances were calculated (Panse and Sukhatme, 1967). The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were computed out according to the method suggested by Burton (1952). Heritability in broad sense (h^2), expected genetic advance as per cent of mean (GA as % of mean) and genotypic and phenotypic correlation coefficients were estimated according to Johnson *et al.* (1955 a,b).

RESULTS AND DISCUSSION

The statistical analysis of variance indicated highly significant differences amongst the genotypes for all the attributes under study. Estimates of V_g , V_{ph} , GCV, PCV, h^2 (broad sense) and GA (as per cent of mean) for characters studied are given in Table 1.

Pods plant⁻¹ had recorded maximum V_g and V_{ph} values whereas, seeds pod⁻¹ showed their minimum values. GCV and PCV were high for traits, like, seed yield plant⁻¹, pods plant⁻¹, pods cluster⁻¹ and branches plant⁻¹. These results are in agreement with those reported by Dabas *et al.* (1982).

Heritability estimates were high (> 70%) for 1000-seed weight, branches plant⁻¹, pods plant⁻¹, pods cluster⁻¹ and days to flowering, indicating that they are less influenced by the environments. These results are in close conformity with the findings of Mathur (1984). The expected genetic advance as per cent of mean varied from 7.38 for days to maturity to 57.16 for pods per plant, which were observed in the descending order pods plant⁻¹ > seed yield plant⁻¹ > pods cluster⁻¹ > seed yield plant⁻¹ > pods Cluster⁻¹ > branches plant⁻¹, thereby indicating the possibility of maximizing genetic gain through selection for these attributes.

Genotypic (r_g) and phenotypic (r_{ph}) correlation coefficients among various characters are presented in Table 2. Seed yield plant⁻¹ showed strongest positive association with pods plant⁻¹ followed successively by pods cluster⁻¹ and clusters plant⁻¹ at genotypic and phenotypic levels. The correlations of seed yield with plant height and branches plant⁻¹ were positive but significant only at phenotypic level.

The positive significant association was obtained between days to flowering and days to maturity both at genotypic and phenotypic levels. However, both these traits exhibited significant positive correlation with plant height and significant negative association with 1000-seed weight. This revealed that the late types had more plant height but decreased seed weight. Plant height had significant negative association with 1000-seed weight. Plant height had

significant and positive association with pods plant⁻¹ both at genotypic and phenotypic levels, while its positive correlation with clusters plant⁻¹ was significant only at phenotypic level. These results indicated that tall plant had more numbers of clusters and pods per plant.

Table 1. Estimates of genotypic variance (v_g), phenotypic variance (V_{ph}), genotypic and phenotypic coefficients of variability (GCV, PCV), heritability in broad sense (h^2), genetic advance (GA) and GA as per cent of mean

Characters	Range	Mean $\pm$ SEm	V _g	V _{ph}	GCP	PCV	h^2 (%)	GA	GA as % of mean
Days to flowering	33.3-47.0	39.48 $\pm$ 1.73	13.26	17.74	9.22	10.67	74.75	6.49	16.43
Days to maturity	76.3-96.0	88.16 $\pm$ 2.32	15.27	23.32	4.43	5.48	65.48	6.51	7.38
Plant height (cm)	37.7-77.3	56.11 $\pm$ 4.88	53.85	89.57	13.08	16.87	60.12	11.72	20.89
Branches plant ⁻¹	0.1-7.3	4.42 $\pm$ 0.55	1.71	2.17	29.63	33.35	78.80	2.39	54.07
Clusters plant ⁻¹	3.8-20.1	14.38 $\pm$ 1.78	7.56	12.32	19.12	24.41	61.36	4.44	30.88
Pods cluster ⁻¹	1.2-5.5	2.54 $\pm$ 0.37	0.60	0.80	30.42	35.18	75.00	1.38	54.33
Pods plant ⁻¹	15.3-59.0	35.81 $\pm$ 5.02	127.95	165.79	31.59	35.96	77.17	20.47	57.16
Seeds pod ⁻¹	5.6-8.8	7.56 $\pm$ 0.35	0.22	0.40	6.22	8.41	55.00	0.72	9.52
1000 seed weight (g)	21.7-35.9	28.45 $\pm$ 0.87	8.10	9.24	10.00	10.68	87.66	5.49	19.30
Seed yield plant ⁻¹ (g)	2.8-11.3	6.74 $\pm$ 1.12	4.63	6.52	31.94	37.91	71.01	3.74	55.49

Branches plant⁻¹ showed significant positive associations (r_g and r_{ph}) with clusters plant⁻¹ and pods plant⁻¹ indicating that plant with more branches led to produce more numbers of clusters as well as pods plant⁻¹. Pods plant⁻¹ had significant positive genotypic and phenotypic correlations with clusters plant⁻¹ and pods cluster⁻¹ but it showed significant negative association with seeds pod⁻¹ at genotypic level.

Table 2. Genotypic (rg) and phenotypic (rph) correlation coefficients among various characters clusterbean

Characters	Days to maturity	Plant height (cm)	Branches plant ⁻¹	Clusters plant ⁻¹	Pods cluster ⁻¹	Pod plant ⁻¹	Seed pod ⁻¹ 1000-seed weight (g)	Seed yield plant ⁻¹
Days to flowering	rg 0.848**	0.667**	0.153	0.080	0.196	0.219	-0.043	-0.437**
	rph 0.616**	0.496**	0.111	0.068	0.151	0.162	-0.023	-0.359**
Days to maturity	rg 0.695**	0.695**	0.076	0.001	0.155	0.128	-0.060	-0.269*
	rph 0.571**	0.571**	0.082	0.097	0.064	0.129	-0.048	-0.247*
Plant height (cm)	rg -0.023	-0.023	-0.023	0.177	0.217	0.352**	-0.148	-0.132
	rph 0.060	0.060	0.060	0.278*	0.126	0.339**	-0.049	-0.141
Branches plant ⁻¹	rg 0.497**	0.497**	0.497**	0.497**	-0.054	0.301**	-0.074	0.187
	rph 0.518**	0.518**	0.518**	0.518**	-0.052	0.339**	-0.034	0.234**
Clusters plant ⁻¹	rg -0.247*	-0.247*	-0.247*	-0.247*	-0.247*	0.545**	-0.110	0.348**
	rph -0.272*	-0.272*	-0.272*	-0.272*	-0.272*	0.534**	-0.018	0.390**
Pods cluster ⁻¹	rg 0.253*	0.253*	0.253*	0.253*	0.620**	0.620**	0.253*	0.586**
	rph 0.582**	0.582**	0.582**	0.582**	0.582**	0.582**	-0.171	0.494**
Pods plant ⁻¹	rg -0.238*	-0.238*	-0.238*	-0.238*	-0.238*	-0.238*	-0.185	0.862**
	rph -0.157	-0.157	-0.157	-0.157	-0.157	-0.157	-0.181	0.812**
Seed pod ⁻¹	rg 0.004	0.004	0.004	0.004	0.004	0.004	-0.038	0.004
	rph -0.012	-0.012	-0.012	-0.012	-0.012	-0.012	-0.012	0.086
1000-seed weight (g)	rg 0.158	0.158	0.158	0.158	0.158	0.158	-0.012	0.158
	rph 0.118	0.118	0.118	0.118	0.118	0.118	-0.012	0.118

*, ** Significant at P = 0.05 and 0.01 respectively.

It was interesting to note that the genotypic and phenotypic correlation coefficients of clusters plant⁻¹ with pods cluster⁻¹ was significant and negative. Thus with increase in number of clusters per plant, the number of pods per cluster decreased. Likewise, pods cluster⁻¹ was inversely correlated with seeds pod⁻¹.

In the present investigation higher GCV, heritability and expected genetic gains were observed for characters viz., pod plant⁻¹, pods cluster⁻¹, branches plant⁻¹ and seed yield plant⁻¹, indicating the predominance of additive gene effects. These results are in conformity with those of Choudhary and Singh (1976). The traits pods plant⁻¹, pods cluster⁻¹ and clusters plant⁻¹ exhibited positive significant genotypic and phenotypic correlations with seed yield, Hence direct selection of individual plant for pods plant⁻¹, pods cluster⁻¹ and clusters plant⁻¹ can be made for the improvement in yield *per se*.

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SOMATIC EMBRYOGENESIS AND PLANTLET REGENERATION IN 'SAFED MUSLI' (*CHLOROPHYTUM BORIVILIANUM*)

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A method for somatic embryogenesis and plantlet regeneration in 'Safed Musli' (*Chlorophytum borivilianum*) is described. Callus was induced from immature zygotic embryos inoculated on MS medium containing 1.0 mg l^{-1} 2,4-D. Initially, callus was slow growing, soft, watery and slimy. After six weeks of growth and subsequent subculture on MS medium containing 0.5 mg l^{-1} 2,4-D, yellow, compact, hard, nodular, shiny somatic embryos were developed. Embryogenic cultures were maintained by repeated subculturing every four weeks on MS medium containing 0.25 mg l^{-1} 2,4-D. Concentration of 2,4-D was further reduced to 0.1 mg l^{-1} for maturation of these embryos. Plantlets could be recovered from 20 per cent of these somatic embryos when inoculated on auxin free MS medium and the cultures were transferred to light. Precocious germination of somatic embryos and profuse rooting was frequently observed.

Key words : *Chlorophytum borivilianum*, embryogenesis, regeneration

Chlorophytum borivilianum Sant. et Fernand. belonging to family Liliaceae is an important medicinal herb of commercial importance in India and has been listed as rare plant (Nayar and Shastry, 1988). The fasciculated storage roots have aphrodisiac properties and form an important ingredient of herbal tonics prescribed in the Ayurvedic system of medicine in India (Kirtikar and Basu, 1975). The natural regeneration of this herb is through tuberous roots that have become scarce in nature because of indiscriminate collection of wild material. Seed germination is only 14-16 per cent (Jat and Bordia, 1990). There is, therefore, need for multiplication and conservation of this medicinal herb using *in vitro* methods.

In vitro propagation enables broad range of species to be cloned rapidly under highly controlled conditions (Hussey, 1986). Though the question of unicellular origin of somatic embryo advocated by Haccius (1978) has remained controversial, the somatic embryogenesis is viewed as having the potential to be the most efficient plant regeneration method, since literally millions of

plants could be produced from a relatively small amounts of cultured cells or tissues. *In vitro* culture of several ornamental species of Liliaceae have been described (Krikorian and Kann, 1986) but very few medicinal species of this family have so far been established *in vitro* (Jha *et al.*, 1984). *In vitro* clonal method for multiplication of *Chlorophytum borivillianum* has been developed in this laboratory (Purohit *et al.*, 1994). Regeneration of Liliaceous plants through somatic embryogenesis has been reported in *Allium sativum* (Abo El-Nil, 1977), *Asparagus officinalis* (Reuther, 1977), *Hemerocallis* spp. (Krikorian and Kann, 1981), *Iris* (Laublin *et al.*, 1991) and *Allium* spp. (Vandervaalk *et al.*, 1992).

In the present communication, somatic embryogenesis and plantlet regeneration in 'safed musli' (*Chlorophytum borivillianum*) derived from *in vitro* cultures of immature zygotic embryos has been reported.

MATERIALS AND METHODS

Fruits of 'safed musli' were collected during August-September, 1992 and 1993 from natural and protected populations in forest areas around Udaipur, Rajasthan. The immature seeds were carefully extracted from the fruits and surface sterilized with 0.1 per cent mercuric chloride (HgCl_2) for 5 min. and washed 4-5 times with sterile distilled water. Immature embryos (2-3 mm) were dissected out with the help of needles under stereomicroscope in laminar flow hood. Embryos were placed horizontally on a Murashige and Skoog's medium (1962) supplemented with $0.1\text{--}50\text{ mg l}^{-1}$ 2,4-D. The pH of the medium was adjusted to 5.8 prior to autoclaving at 15 lbs pressure psi. Cultures were maintained by subculturing every three weeks on fresh medium containing 0.25 mg l^{-1} 2,4-D and 100 mg l^{-1} ascorbic acid. Cultures were kept in dark at $28^\circ\text{C} \pm 2^\circ\text{C}$ and 50-60 per cent relative humidity. For maturation of embryos, cultures were kept on medium containing 0.1 mg l^{-1} 2,4-D. Mature embryos were finally transferred to auxin-free medium and kept under light conditions (2000 lux light intensity for 16 h/day) for germination. Ascorbic acid (100 mg/l) was invariably added in the medium. Hand sections of shoot primordia and developing shoots were examined under stereomicroscope to understand the developmental process during plantlet formation.

RESULTS AND DISCUSSION

Callus induction was observed in embryos on the 10th day after inoculation on the MS medium containing 0.1 to 5.0 mg l^{-1} 2,4-D. However, the optimum response was observed in the presence of 1.0 mg l^{-1} 2,4-D (Table 1). Initially the growth of callus was slow and the callus appeared soft, watery and slimy. By six weeks, the callus became yellow, compact, hard, nodular and shiny somatic embryos appeared on callus (Fig. 1A). The later embryogenic cultures were isolated from former non-embryogenic cultures and maintained to medium

Table 1. Effect of 2,4-D on callus induction from zygotic embryos of *Chlorophytum borivillianum* (Observations recorded after 4 weeks)

MS + 2,4-D (in mg l ⁻¹)	No. of embryos inoculated	% response	Callusing
Control	10	10	+
0.1	10	80	++++
1.0	10	90	+++++
2.0	10	80	+++
5.0	10	20	+

+ Poor

++ Moderate

+++ Good

++++ Profuse

+++++ Intense

containing 0.25 mg l⁻¹ 2, 4 D and 100 mg l⁻¹ ascorbic acid. Addition of ascorbic acid was found useful for healthy growth of the cultures. Reduction of 2, 4-D from 0.25 mg l⁻¹ to 0.1 mg l⁻¹ was most suitable for embryo maturation under dark conditions. Embryogenic cultures kept on 0.1 mg l⁻¹ 2,4-D for prolonged periods induced precocious germination and profuse rooting (Fig. 1B).

Mature somatic embryos were transferred on medium without growth regulators for germination and were kept under light conditions. Twenty one per cent (42 out of 200) of the inoculated embryos produced shoots and roots alongwith a mixed population of precociously germinating embryos showing profuse rhizogenesis (Fig. 1C). These germinating embryos were separated and transferred to fresh media for completion of germination (Fig. 1D) and plantlet development (Fig. 2A). In subsequent subculture, profuse tillering was observed in the developed plantlets (Fig. 2B). Only a few plants could be established in soil till maturity. They showed very poor growth and storage root development. Histological examinations indicated wide variation of structures from abnormal embryo like structures to globular masses of callus. Sections through somatic embryos or plantlets revealed typical cellular organisation of shoot primordium (Fig. 2C & D) and root meristem.

Production and maintenance of vigorous callus from tissues of Liliaceae family have traditionally been viewed as difficult (Krikorian and Katx, 1968). 2,4-D has been considered the most important auxin to induce callus and somatic embryogenesis in most of the monocots (Choi and Sung, 1989). In the present study also 2,4-D has been used to induce callusing and somatic embryogenesis. The requirement of high auxin levels during initiation phase of embryogenesis has been reported (Choi and Sung, 1989). However, inhibition of development and growth of the shoot meristems can occur if young embryos are not transferred to a low auxin or zero-auxin medium (Parrott *et al.*, 1988).

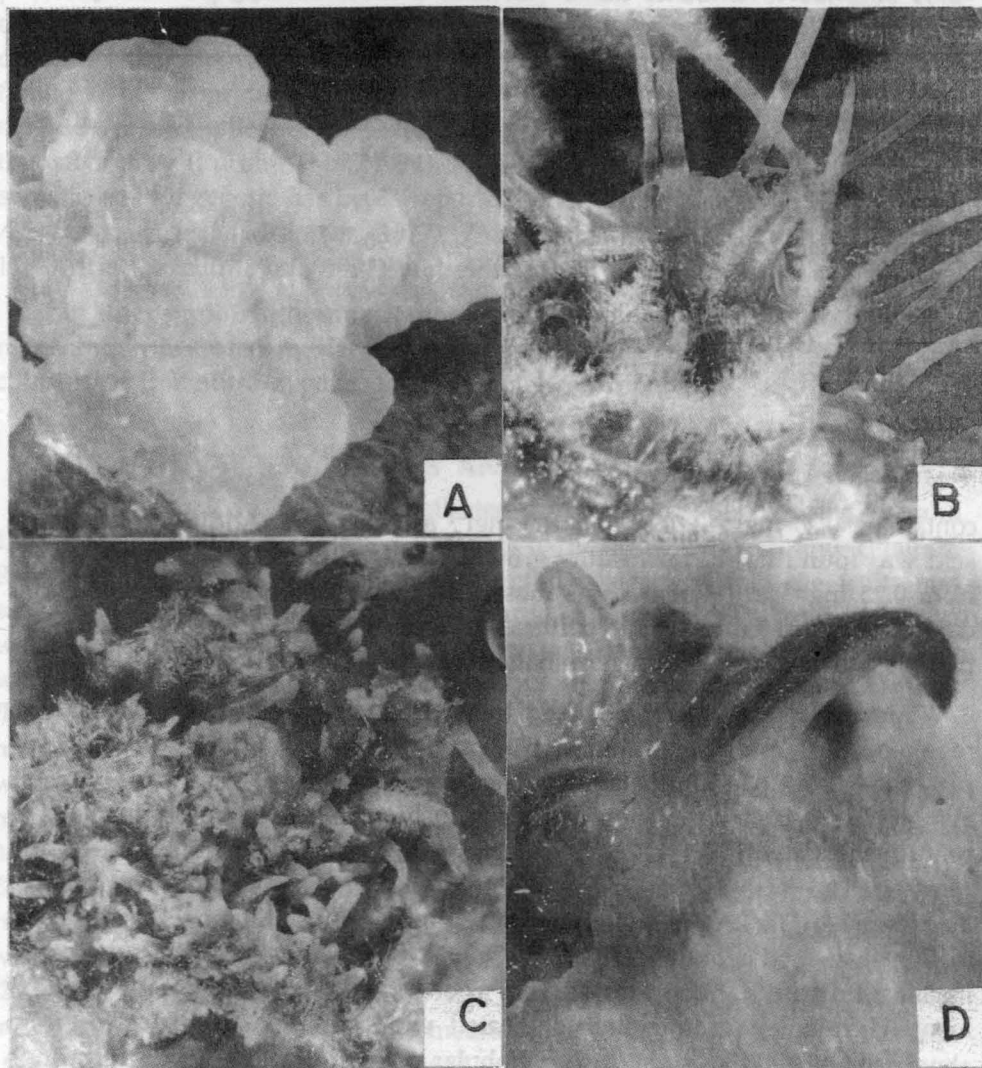


Fig. 1 (A-D). Somatic embryogenesis and plantlet regeneration in *Chlorophytum borivillanum* Sant et Fernand. Embryogenic cultures from immature zygotic embryos on MS medium containing 1.0 mg l^{-1} 2,4-D (A). Precociously germinating somatic embryos showing profuse rhizogenesis (B). Germinating mature embryos in mixed population of precociously germinating embryo (C) and regeneration of complete plantlet (D).

In the present investigation, the gradual reduction of auxin from the medium improved the embryo maturation and the complete removal of 2,4-D from the medium favoured germination.

The present investigation demonstrates the potential of immature zygotic

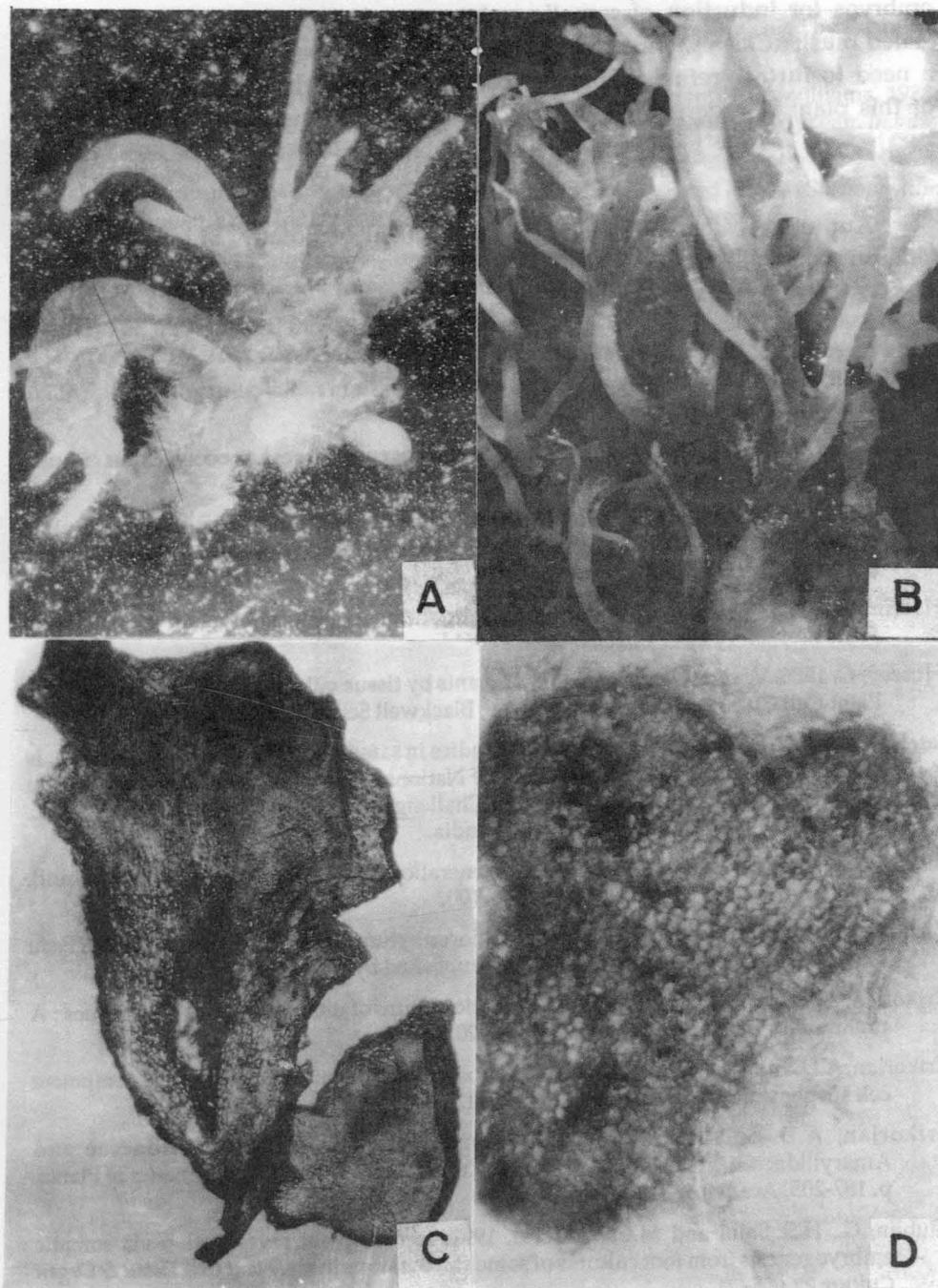


Fig. 2 (A-D). Development of plantlet and histology of regenerated shoot of *Chlorophytum borivillianum* Sant et Fernand. Regeneration of complete plantlet, with distinct roots and shoots (A). Profuse tillering in the regenerated plantlet (B). Longitudinal (C) and transverse sections (D) of regenerated shoots showing cellular organization and vascular system.

embryos for induction of somatic embryogenesis and plantlet regeneration in 'safed musli' (*Chlorophytum borivillianum*) for mass propagation. There is however, a need to further refine the proper conditions for high frequency regeneration of this plant in order to use this technology for commercial micropropagation.

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SEED AND SEEDLING CHARACTERS IN RELATION TO STORABILITY IN SORGHUM (*SORGHUM BICOLOR* (L.) MOENCH)

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The analyses of means, variance and correlations were carried out on 16 germplasm accessions of sorghum after storing them for two years under ambient storage conditions. The study revealed the difference among accessions for their storability. Several seed and seedling characters were found to be correlated among themselves and with the viability of accessions after two years of storage.

Key words : Sorghum, seedling characters, storability, conservation

The extent and range of seed deterioration reflect the genotype differences and pre-storage history of seed lots (Delouche, 1968). The differential viability and vigour of genotypes having the same pre-storage history may be due to other factors like morphological, physiological and anatomical differences of the seed accessions (Rao *et al.* 1987; Barla-Szabo *et al.*, 1990). Agrawal *et al.* (1981) and Krishnaswamy (1986) reported genotype differences for seed longevity in Sorghum. The present study was aimed at examining the variation and interrelationships of a few seed and seedling characters associated with the storability of sorghum germplasm accessions as indicated by their differential viability and vigour after two years of storage under ambient conditions.

MATERIALS AND METHODS

The experimental material for the present study comprised 16 sorghum accessions selected at random from 150 accessions at the National Bureau of Plant Genetic Resources, Regional Station, Akola during *kharif*, 1989 but could not qualify the prescribed viability standard (85% and above), for long term conservation in the National Genebank at NBPGR. Seeds of these accessions were kept in cloth bags under ambient storage conditions at NBPGR Headquarters until September 1991. Seed moisture content of the sampled accessions was recorded using constant weight oven method (Cromarty *et al.*, 1982). The random samples of 500 seeds were drawn from each accession and their

weight was recorded. The volume of water displaced by 500 seeds in a measuring cylinder was recorded as the seed volume while seed density was found from ratio of seed weight and volume. The seed colour was recorded on visual scoring (1-5 scale). The score of 1 was assigned to very dull chalky seed colour and 5 to bright creamy seeds. The germination tests were carried out following the procedure prescribed by International Seed testing Association (ISTA, 1985a) for this crop, using 50 seeds replicated thrice. The germination was recorded after 7 days and number of normal abnormal seedlings and dead seeds were counted according to criterion in ISTA (1985 a, b). For recording seedling vigour, the shoot length, coleoptile length and root length were measured on 15 randomly selected seedlings in three replicates of 25 seeds each kept separately for germination on moist paper towels in a germinator.

Leachate analysis

Three replicates of 25 seeds each were prepared and soaked in 25 ml of distilled water for 16 hours at $25\pm^{\circ}\text{C}$. The leachate electrical conductivity was recorded in ml mho/cm² through an Elico cm 82 T conductivity bridge.

Statistical analysis

The data were analysed for means and variance. Phenotypic correlation coefficients were also computed using MSTAT between seed viability and other seed characteristics.

RESULT AND DISCUSSIONS

Analysis of variance for seed and seedling characters (Table 1) revealed highly significant differences between accessions for various viability and vigour parameters except for the frequency of abnormal seedlings which was significant only at 5 per cent level of significance. The coefficient of variation was 63.4 for this trait. The magnitude of variance due to difference between accessions was highest for the leachate electrical conductivity indicating the potential of this parameter in detecting genotypic differences for viability in sorghum. Mean data (Table 2) indicated IS-671, IS-1491, IS-2646 and IS-2872 retaining the viability of 82 per cent, 80 per cent, 80 per cent and 79 per cent respectively after two years of storage under ambient conditions. Whereas, the accessions IS 3982 and IS 18469 exhibited only 17 per cent viability after the same period of storage indicating very poor storability. The accessions showing relatively better storability as indicated by their better viability after 2 years of storage, were also found to be exhibiting bright seed colour and relatively high shoot and coleoptile lengths. The germplasm accessions which showed

very high deterioration were also found to exhibit very high leachate electrical conductivity reflected through the correlation studies (Table 3).

Table 1 : ANOVA for seed and seedlings traits in sorghum

Source	D.F.	Mean Sums of Squares						
		Shoot length	Coleoptile length	Root length	Normal seedlings	Abnormal seedling	Dead seeds	leachate electrical conductivity
Replication	2	6.97	4.20	16.47	3.58	1.69	0.25	814.4
Accessions	15	18.45**	16.98**	18.21**	109.22**	3.08*	100.17**	8151.9**
Error	30	5.17	2.24	3.64	10.18	1.71	8.47	272.9
C.V.%		18.11	14.48	18.11	20.9	63.4	38.2	12.5
S.E.(Mean)		1.31	0.86	1.10	1.84	0.75	1.68	11.68

**Significant at $p = 0.01$, *Significant at $p = 0.05$

The seed moisture content which is a well known factor determining the storage life of the orthodox seeds (Roberts 1986, 1991) was found to be significantly negatively correlated with number of dead seeds and leachate electrical conductivity. Seed weight was found to be significantly positively correlated with seed volume and leachate electrical conductivity and significantly negatively correlated to seed colour and seedling shoot length. The correlation of seed colour was significant and positive with shoot and negative with leachate electrical conductivity. This indicated that bright creamy seeds produced vigorous seedlings and released less water soluble nutrients with low electrical conductivity of the leachate. As expected, seedling vigour as inferred from shoot length was found to be positively significantly correlated with coleoptile length and frequency of normal seedlings and was negatively correlated with frequencies of abnormal seedlings, dead seeds and leachate electrical conductivity. Similar correlation coefficients were observed for coleoptile length. These results revealed that shoot length and coleoptile length of seedlings are good indices of vigour in sorghum. The frequency of dead seeds showed highly significant positive correlation with leachate electrical conductivity. therefore, leachate electrical conductivity in sorghum can be considered as the good indicator of seed viability.

Table 2 : Mean of sorghum germplasm for some seed and seedling characters

S. No.	Accession	Initial germination %	Germ ination after 2 years of storage %	Seed density	Seed colour (1-5) score	Shoot length (cm)	Cole optile length (cm)	Root length (cm)	Abnormal seedlings %	Dead seeds %	Lea- chate Electrical conductivity ml mho/cm ²
1.	IS-671	84	82	1.11	4	18.2	14.9	7.8	9	9	95.7
2.	IS-825	65	59	0.90	4	10.9	10.4	9.8	13	28	163.0
3.	IS-1035	80	77	1.08	3	15.5	11.7	15.6	5	18	194.0
4.	IS-1491	84	80	1.07	3	14.2	10.4	12.2	8	12	174.7
5.	IS-2235	45	22	1.13	2	10.5	7.4	9.8	14	64	416.7
6.	IS-2646	84	80	1.04	3	14.6	14.2	7.0	10	10	103.7
7.	IS-2872	83	79	1.20	1	11.6	9.9	11.5	5	16	159.6
8.	IS-3982	40	17	1.24	2	10.3	10.0	9.2	7	76	326.0
9.	IS-4342	78	75	1.07	5	14.1	9.3	8.8	8	17	84.0
10.	IS-10295	75	68	1.03	4	13.2	10.4	11.6	2	26	284.0
11.	IS-10934	73	68	1.15	2	13.8	13.4	10.2	4	28	224.0
12.	IS-18469	35	17	1.03	2	11.1	8.2	13.3	6	77	526.0
13.	IS-19071	62	57	0.99	4	13.5	12.1	12.7	9	34	304.0
14.	IS-19363	68	63	1.16	3	10.0	8.6	7.7	13	24	294.0
15.	IS-20502	80	74	1.12	4	10.4	7.2	13.3	12	14	264.0
16.	IS-21726	60	45	1.13	2	8.8	7.9	7.9	14	41	424.0
SE (d)		NR	2.60	NR	NR	1.86	1.22	1.55	1.06	2.37	13.5
CD AT 5%		NR	5.31	NR	NR	3.87	2.45	3.06	2.25	4.90	27.6

NR - Non-replicated

Table 3 : Phenotypic correlation coefficients for sorghum germplasm accessions

Character	Seed Weight	Seed volume	Seed density	Seed colour	Shoot length	Coleoptile length	Root length	Normal seedling	Abnormal Seedling	Dead seeds	leachate Elect-conductivity
Seed moisture	0.24	0.26	0.20	0.003	-0.05	0.05	0.18	-0.67**	-0.02	0.71**	0.53**
Seed weight	-	0.95**	0.36	-0.55*	-0.53*	-0.34	0.14	-0.35	0.32	0.32	0.59*
Seed volume	-	-	0.12	-0.41	-0.41	-0.25	0.28	-0.26	0.23	0.24	0.58
Seed density	-	-	-	-0.52*	-0.19	-0.22	-0.23	-0.26	-0.03	0.26	0.23
Seed colour	-	-	-	-	0.53*	0.42	-0.21	0.28	-0.03	-0.30	-0.61**
Shoot length	-	-	-	-	-	0.84**	0.08	0.61**	-0.51*	-0.55*	-0.70**
Coleoptile length	-	-	-	-	-	-	-0.16	0.55*	-0.44	-0.50*	-0.64**
Root length	-	-	-	-	-	-	-	0.02	-0.39	0.36	0.24
Normal seedling	-	-	-	-	-	-	-	-	-0.36	-0.98**	-0.75**
Abnormal seedling	-	-	-	-	-	-	-	-	-	0.19	0.20
Dead seeds	-	-	-	-	-	-	-	-	-	-	0.76**

**Significant at $p = 0.01$, * Significant at $p = 0.05$

Selvaraj and Ramaswamy (1984) studied the storability of Sorghum and observed that maternal influence is involved in governing the loss of viability in this crop. Agrawal *et al* (1981) observed the influence of better storer parents in influencing the loss of viability of sorghum hybrids. They also noted that if the initial viability of a genotype is low, such genotypes lose seed viability faster during storage. The results obtained in the present study are in conformity to those of Agrawal *et al* (1981).

Although several physiological and biochemical tests have been developed for evaluating seed vigour and viability in different crops (Hall and Wiesner, 1990), these relationships have not been extensively studied in sorghum. Ching and Schoolcraft (1968) observed that electrical conductivity of the seed leachate correlates well with germination of "Dixie" Crimson clover (*Trifolium incarnatum* L.). In the present study also the leachate electrical conductivity appeared to

be a good indicator of the degree of deterioration of sorghum seeds. This character showed meaningful correlations with 8 of the 11 characters studied.

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BIOCHEMICAL CHANGES AND CONSERVATION OF WATERMELON (*CITRULLUS LANTAUUS* THUNB.) GERMPLASM

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Watermelon (*Citrullus lanatus* Thunb.) germplasm is commonly preserved in the form of seeds, which is simple, inexpensive and practical means of conservation. Watermelon seeds are short lived for two years under ambient conditions. Seeds of cv Arka Manik having 8.0 per cent moisture were packed in polyethylene (200 gauge) and aluminium foil laminated bags (paper-foil- polyethylene) and stored at ambient (16-35°C), low (5°C) and sub- zero (-20°C) temperatures. With the low temperature storage of seeds, the longevity was extended to 5 years without decline in seedling vigour. Both polyethylene and laminated bags were effective for retaining the viability for 5 years at 5°C and -20°C. Biochemical changes were studied in stored seeds, as a result there was increased leaching of electrolytes, soluble sugars and free amino acids and decreased in dehydrogenase activity on deterioration. Storage of seeds in polyethylene or laminated bags at 5°C or -20°C was effective in conserving germplasm in the form of seeds for five years without decline in vigour.

Key words : Watermelon, *Citrullus lanatus*, conservation, germplasm, biochemical changes

Germplasm plays an important role in crop improvement for high yield, better quality, resistance to pests, diseases and stress conditions. Improper handling and storage of germplasm causes invaluable loss of genetic resources. Seeds are widely used for conservation of genetic variability in several vegetable crops including watermelon owing to convenient and less expensive for the operation. Seed loses viability rapidly under ambient conditions and it is predominantly dependent on storage conditions *viz.*, temperatures and humidity (Abdul-Baki and Anderson, 1972). High temperature and high humidity promote seed deterioration and shorten the longevity period in cucurbits (Villareal *et al.*, 1972). Such seeds are less vigorous and reduce the yield (Frohlich and Henkel, 1964). Loss of seed viability is associated with certain changes in seed, causing excessive leakage of electrolytes, soluble sugars (Doijode, 1985) and amino acids (Givelberg *et al.*, 1984) from seeds and decrease in enzymatic activity in seeds (Copeland, 1976). The present experiment deals with increasing longevity of watermelon seeds by selecting suitable containers for low temperature storage and studying biochemical changes in relation to loss of viability.

MATERIALS AND METHODS

Seeds of watermelon cv Arka Manik were extracted from fully ripe fruits and dried to 8.0 per cent moisture. Seeds were stored in polyethylene (200 gauge) and aluminium foil laminated bags (Paper-foil-polyethylene) at low (5°C) and sub-zero (-20°C) temperatures. Seed viability was expressed in percentage of germination. Seeds were germinated in moist rolled towel at alternate temperatures of 20-30°C for 16 and 8 hours, respectively, in seed germinator. Seedling length was measured on four days old seedlings. Dry weight was recorded on seedlings dried at 65° C for 48 hours. Seedling vigour was compared by means of indices I and II which were calculated by multiplying percentage of germination with seedling length and dry weight, respectively. For biochemical studies, seeds were surface sterilized with 0.1 per cent mercuric chloride, washed thrice with sterile water and surface dried with tissue paper. Seeds were soaked in 15 ml sterile water for 18 hours at 25°C. Electrical conductivity of seed leachates was measured by conductivity meter. Soluble sugars were analysed as per the method of Dubois *et al.* (1958), and free amino acids according to procedure of Lee and Takahashi (1966) in leachate. Dehydrogenase activity was measured by reduction of tetrazolium salt (Kittock and Law, 1968) in stored seeds.

RESULTS AND DISCUSSION

Seed viability and longevity were significantly affected by storage temperatures and containers. The percentage of seed germination was rapidly decreased in ambient storage, the rate of reduction was more in seeds stored in polythelene bags than aluminium foil laminated pouches. Seed germinability was reduced by 50 per cent after 2 years of storage, and there was no germination at the 3rd year of storage (Fig.1). The initial seed viability maintained for 5 years at 5°C and -20°C storage. Seeds stored in polyethylene and laminated bags effectively retained viability at low temperature (Fig.2). Seedling vigour, comprising vigour indices I and II, were rapidly decreased in ambient stored seeds while it maintained in seeds stored at 5°C and -20° C (Table 1). The retention of seedling vigour was greater in seeds stored in laminated pouches than polyethylene bags (Table 2). The electrical conductivity of seed leachate was higher in ambient stored seeds than seeds stored at 5°C or -20°C. Leaching of soluble sugars doubled in ambient than low temperature stored seeds. Similarly there was increase in quantity of amino acids in leachates of ambient stored seeds, which was coincided with loss of seed viability (Table 3). There was sharp decline in dehydrogenase activity in ambient stored seeds as compared to seeds stored at 5°C or -20°C. This indicates decrease in seed viability associated with increase in leaching of metabolites and decrease in dehydrogenase activity in seeds. Loss of germinability was positively correlated with extent of leakage in terms of conductivity and soluble sugars (Shamasherry

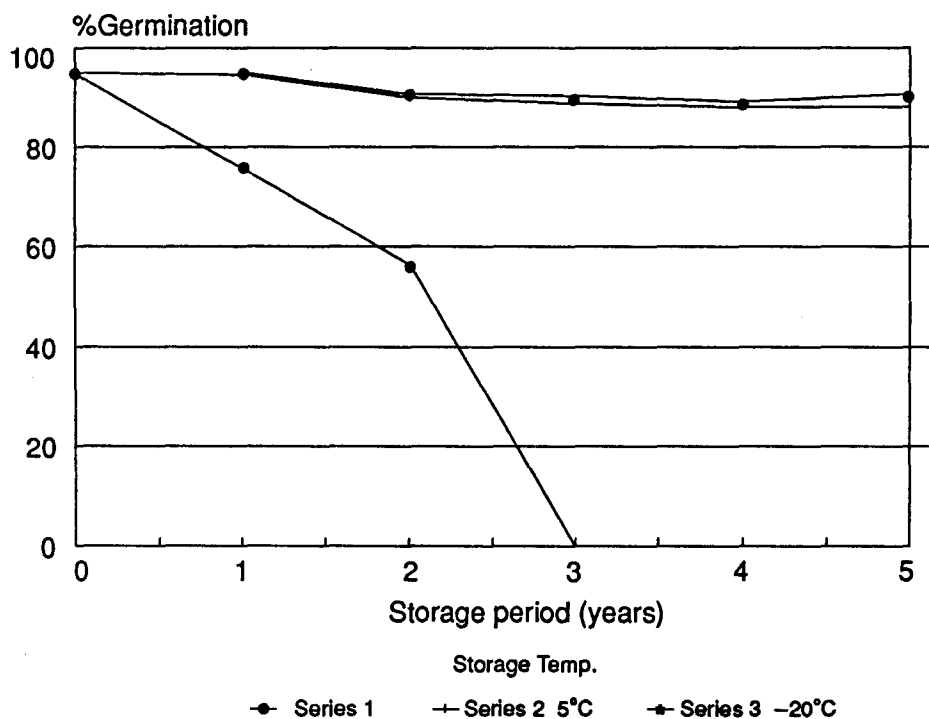


Fig. 1. Seed storability as influenced by temperatures in watermelon

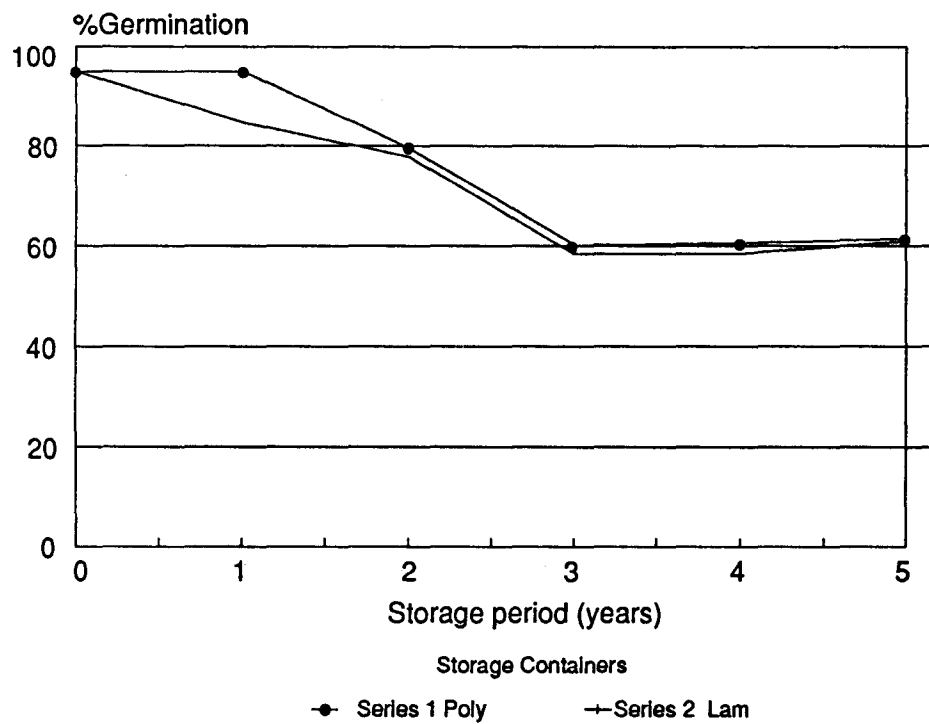


Fig. 2. Influence of packaging on storability of watermelon seeds

and Banerji, 1979). This excessive leakage was attributed to disruption on cell membrane (Schoettle and Leopold, 1984).

Table 1. Vigour Index-I of seedling during storage of watermelon seeds

Storage temperature	Storage containers	Storage period (years)				
		1	2	3	4	5
Ambient	Poly	250	51	0	0	0
	Lam	327	79	0	0	0
5°C	Poly	385	304	337	369	352
	Lam	407	371	375	400	360
-20°C	Poly	373	337	390	379	360
	Lam	431	357	425	375	275

C.D. at 5% = 62.8

Table 2. Vigour Index- II of seedling during storage of watermelon seeds

Storage temperature	Storage containers	Storage period (years)				
		1	2	3	4	5
Ambient	Poly	928	768	0	0	0
	Lam	1269	1100	0	0	0
5°C	Poly	1615	1800	1599	1875	1807
	Lam	1687	1855	1678	1947	1819
-20°C	Poly	1689	1894	1429	1972	1864
	Lam	1754	2047	1831	2067	1901

C.D. at 5% = 198.6

Table 3. Biochemical changes in seed and leachate as influenced by temperatures after five years of storage

Storage temp. (°C)	Storage Containers	E (μv)	Sugars (mg/g)	Amino acids (mg/g)	DHA (A480)
Ambient	Poly	113 ± 1.8	6.20 ± 0.31	0.85 ± 0.00	0.21 ± 0.00
	Lam	110 ± 3.5	6.02 ± 0.38	0.78 ± 0.04	0.32 ± 0.00
5	Poly	80 ± 0.7	3.81 ± 0.07	0.61 ± 0.04	0.67 ± 0.00
	Lam	79 ± 0.7	3.76 ± 0.00	0.52 ± 0.01	0.71 ± 0.00
-20	Poly	80 ± 1.4	3.44 ± 0.19	0.69 ± 0.01	0.58 ± 0.00
	Lam	75 ± 0.7	2.87 ± 0.06	0.64 ± 0.01	0.72 ± 0.01

Watermelon seeds were viable for two years and retention of viability was greater in laminated than polyethylene bag under ambient conditions. The rate of deterioration was faster at high temperature and high moisture while germination decline slowly at cooler temperature (Harrington, 1972). Seed viability reduced rapidly under ambient temperature (Villareal *et al.*, 1972) and longevity prolonged with low temperature storage of seeds (Boros and Hadnagy, 1969). Seedling vigour also preserved at low temperature. With decrease in vigour, certain changes occurred in seeds, which are useful for quick prediction of seed quality. The leaching of electrolytes, soluble sugars and amino acids was more at ambient temperature than at 5°C or -20°C. Fonseca *et al.* (1980) reported that seeds stored in ambient temperature begins to deteriorate faster and show low germination and low vigour. Polyethylene and laminated pouches were ideal packaging material for storage at low or sub-zero temperature. Storage of seeds either in polyethylene or laminated pouches at 5°C or -20°C was effective for conserving watermelon germplasm for 5 years without loss of vigour.

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VARIATIONS AND CORRELATIONS FOR SEED AND SEEDLING CHARACTERS IN SOYBEAN (*GLYCINE MAX* MERRILL) GERMPLASM

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The present study was carried out to examine the variability and inter-relationship for various characteristics recorded on seed and seedlings of soybean germplasm being conserved in the National Genebank at the National Bureau of Plant Genetic Resources, New Delhi. The study revealed significant differences between soybean accessions for seed viability parameters namely normal, abnormal seedling, dead seeds, seedling vigour and such as seed weight, volume and colour.

Key words : Soybean, *Glycine max*, variations, correlations, seedling characters

The worth of the germplasm seed for their long term conservation is assessed by evaluating seed viability and vigour when the seed is received and during the course of their storage in the genebank. Influence of seed size, seed weight and density on their laboratory and field performance has been extensively studied and documented (Singh *et al.*, 1972; Tiwari *et al.*, 1976; Borba, 1987; Unsrising, 1988; Song *et al.*, 1990). The objective of the present study was to examine the magnitude of variability for seed germination related characters. The relationships between some of the seed characteristics such as seed weight, volume, density, colour and seed leachate electric conductivity among themselves and with the seed viability parameters such as germination, number of normal, abnormal seedlings and dead seeds and seedling vigour have also been examined.

MATERIAL AND METHODS

The seed material utilised for the present investigation comprising 30 soybean germplasm accessions exhibited variation in seed size, shape and colour. These seed samples were drawn from over 400 soybean germplasm accessions being maintained in NBPGR Genebank. A list of the germplasm utilised is given in table 1. Observations were recorded on 100 seed weight (g), seed volume, seed density and seed colour. The volume of the 100 seeds was measured by the volume of water displaced by these seeds in the

measuring cylinder. The seed density was computed as a ratio of weight and volume of the seed. Visual scoring on 1 to 5 scale was done for seed colour. The initial phase of each germination test comprised slow rehydration to 14-16 per cent moisture content by humidifying seeds above water in the dericator, to avoid imbibition damage. This required 2-4 days. The germination tests were carried out following the procedure prescribed by the International Seed Testing Association (ISTA, 1985 a) for this crop, using 50 seeds replicated thrice. The germination counts were taken after 7 days and numbers of normal, abnormal, dead and hard seeds were recorded according to criterion of normal germination (ISTA, 1985a, b). For seedling vigour, shoot lengths of normal seedlings in three replicates of 25 seeds each kept separately for germination, on pencil lined paper towels, were measured and mean was calculated for each replication.

Table 1. List of Soybean germplasm lines

S.No.	IC/EC No.	Origin	Year of introduction/ collection	S.No.	IC No.	Origin	Year of introduction/ collection
1.	EC-14483	AUSTRALIA	1959	16	IC-7562	NAMCHI	1960
2.	EC-15627	GERMANY	1959	17	IC-10036	H.P.	1962
3.	EC-30208	U.S.A.	1964	18	IC-10039	H.P.	1960
4.	EC-34121	HUNGARY	1965	19	IC-13048	W.B.	1966
5.	EC-36894	TAIWAN	1965	20	IC-13054	W.B.	1966
6.	EC-36956	JAPAN	1965	21	IC-18741	H.P.	1973
7.	EC-36999	USA	1966	22	IC-18764	H.P.	1973
8.	EC-39369	AUSTRALIA	1965	23	IC-24993	MIZORAM	1975
9.	EC-65767	USA	1969	24	IC-24068	U.P.	1974
10.	EC-98410	USSR	1971	25	IC-2500	MIZORAM	1975
11.	EC-121391	TAIWAN	1977	26	IC-25766	A.P.	1975
12.	EC-141430	USA	1981	27	IC-37187	SIKKIM	1980
13.	IC-2051	NEPAL	1953	28	IC-37191	SIKKIM	1980
14.	IC-2064	W.B.	1953	29	IC-37197	SIKKIM	1980
15.	IC-2065	W.B.	1953	30	IC-37203	SIKKIM	-

W.B. - West Bengal, H.P. - Himachal Pradesh, U.P. - Uttar Pradesh, A.P. - Arunachal Pradesh; IC and EC represents Indigenous and Exotic collections

Leachate analysis

Three replicates of 10 seeds each were prepared and soaked in 25 ml of distilled water for 16h at 25 + 1°C. Electrical conductance of the leachate

was measured in a wheat-type conductivity bridge (Elico CM 82 T) and recorded in ml mho/cm²

Statistical analysis

The replicated data was subjected to standard analysis of variance. The simple correlation co-efficients between seed viability and other seed characteristics were computed using MSTAT.

RESULTS AND DISCUSSION

The analysis of variance for five seed viability related traits has shown high significant differences between soybean accessions for normal seedlings, dead seeds, seedling vigour and leachate electrical conductivity (Table -2). The differences for the numbers of abnormal seedlings were significant only at probability 0.5 which indicated relatively low occurrence of abnormal seedlings. The significant differences in soybean accessions for these traits are expected when the germplasm represent a large number of accession from where these have been drawn.

Table 2. ANOVA (Soybean germplasm)

Source	D.F.	Normal seedling	Abnormal seedling	Dead seeds	Seedling vigour	Leachate E.C.ml mho/cm ²
Rep.	2	2.50	0.025	3.60	0.077	13.07
Accessions	29	87.979**	4.172*	83.82**	26.85**	1039.75**
Error	58	5.237	2.078	6.81	1.04	35.67
CV%		14.21	10.87	36.0	10.68	15.93
S.E.		1.87	1.18	2.13	0.83	4.88

**Significant at p = .01, *Significant p = .05.

The correlation coefficients between seed morphological characters such as seed weight, volume, seed density, seed colour among themselves and with various seed germination parameters have been presented in table 3. Seed weight showed significant positive correlations with seed volume and seed density. This trait was also significantly correlated with seed leachate electrical conductivity. Seeds with high density showed significant positive correlation with seedling vigour. However, the occurrence of more number of abnormal seedlings from high density seeds was indicated by significant positive correlation between these two traits which may be due to the accumulation of

damages to macromolecules within the embryonic tissue (James 1967; Koostra and Harrington 1969; Villiers, 1972). The results of these experiments have shown fundamental differences between large and small seeds with respect to their survival ability. Based on these results, it can be postulated that the accumulation of such damages may be more in larger than in smaller seeds. This view has been supported by the results obtained in the present study with the greater frequency of seedling abnormalities resulting from larger seeds.

Table 3. Correlation coefficients (Soybean germplasm)

Characters	Seed of volume	Seed density	Seed colour	Leachate E.C.	Normal seedling	Abnormal seedling	Dead seed	Seedling vigour
Seed weight	.971**	.534*	-.376	.747**	-.233	.313.	.216	-.081
Seed volume	-	.328	-.346	.776**	-.319	.209	.318	-.081
Seed density	-	-	-.191	.137	.328	.431*	-.387	.444*
Seed colour	-	-	-	-.495	.443*	-.387	-.425	.177
Leachate E.C.	-	-	-	-	-.657**	.279	.647**	-.347
Normal seedls.	-	-	-	-	-	-.343	-.973**	.793**
Abnormal seedls.	-	-	-	-	-	-	.160	-.280
Dead seeds	-	-	-	-	-	-	-	-.746**

**Significant at $p = .01$, * Significant at $p = .05$.

Seed colour showed significant negative correlation with leachate electrical conductivity and positive correlation with number of normal seedlings. This indicates that dull colour seeds deteriorate faster and bright creamy seeds produce more normal seedlings. Among several methods for testing for seed vigour, the electro-conductivity test (Bradnoc and Mathews, 1970) and measuring the length of seedlings which is used to determine physiological seed vigour (Yaklich and Kulik, 1979; Perry, 1981; Catizone and Lavato, 1987), have been found very effective for comparing the planting value of seed lots and accessions. Both these methods have been used in the present study. It is interesting to note that leachate electrical conductivity was significantly nega-

tively correlated with numbers of normal seedlings positively with number of dead seed indicating that this trait is a good indicator of seed deterioration. Frequency of normal seedling was negatively associated with occurrence of dead seed and it was highly positively correlated with seedling vigour. Therefore, the frequency of normal seedlings in soybean appear to be the good indicator of seed vigour and storage potential.

Present result clearly demonstrate the usefulness of recording seed density and colour data on the germplasm accessions received for longterm conservation as these traits have the bearing on seed storage potential and seed viability parameters.

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GUAYULE (*PARTHENIUM ARGENTATUM* GRAY) — AN UNDER-EXPLOITED RUBBER YIELDING PLANT FOR EXPLOITATION IN WASTELANDS

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Guayule, a desert shrub native to Mexico and South-west Texas (USA) is currently being developed as a supplementary source of natural rubber in addition to *Hevea brasiliensis* rubber. Natural rubber accounts for about 30% of world's total rubber production and is being preferred in comparison to synthetic rubber due to certain unique characteristics of elasticity, flexibility, resilience and low heat build up. Rubber in the guayule plant is located throughout the stem, branches and roots and is ca 5-12 %. The paper reviews the history of guayule, its botany, rubber and co-products, genetics and breeding behaviour, agroclimatic requirements, propagation and research work carried out under coordinated research programme in India.

There are many species of plants which contain rubber but only few have been exploited for commercial use. These are *Hevea brasiliensis* Muel. Aug. (the common rubber/Brazilian rubber) and the guayule shrub (*Parthenium argentatum* Gray). This is the only plant other than *Hevea brasiliensis* which has been found to contain latex in sufficient amounts and it can be used as a commercial source of natural rubber. Natural rubber is in great demand since transportation depends heavily on it as it is the basic ingredient of tyres. Natural rubber is ingredient of many other elastic products also that require high tensile strength, durability and low heat build up. So the rubber synthesised from petroleum products cannot completely replace natural rubber. Moreover, natural rubber is a renewable resource in comparison to synthetic one.

At present, *Hevea* tree provides the natural rubber used all over the world. Cultivation of this tree is restricted to a limited tropical zone, mainly in south-east Asia. Any biological change in this small zone could endanger world's supply of natural rubber from *Hevea*. Therefore, there should be an alternative substitute to rubber tree which can be grown in other kinds of agroecological zones also. 'Guayule' is such an alternate source for commercial rubber production which can be grown suitably in wastelands and marginal areas of semi-arid regions.

History of Guayule

Guayule plant is a native of Chihuahuan desert of north-central Mexico and south-western United States (Hammond and Polhamus, 1965). Some explorers have seen native Americans in Mexico playing with a bouching ball made from guayule rubber. But the commercial utilization of rubber began in 1888 and extraction plants were set up for rubber production from native wild populations (Lloyd, 1911). Commercial utilization of guayule from natural plant stands dates back to the late 1980s. Domestication and development of the first guayule cultivar 593, was initiated in 1910 (Mc. Callum, 1941). In 1942, the Emergency Rubber Project, was initiated to domesticate and develop guayule as an alternative rubber crop during World War II. Unfortunately, the programme was abruptly terminated in 1946, but the USDA-ARS breeding programme was continued until 1959 at a minimal level. Hammond and Polhamus (1965) published a comprehensive summary of the research activities and accomplishments made during 1942 to 1959 period. No cultivars were formerly released during this period. They have provided sources of germplasm used in developing 31 guayule selections, 24 of which provide the major germplasm pool for the current USDA-sponsored cultivar developmental efforts initiated in the late 1970.

Germplasm and cultivar development is a major component of the current commercialization effort. Breeding and genetic research in the USA is concentrated in four closely cooperating locations : University of Arizona, Tucson; USDA-ARS, Phoenix, AZ; University of California-Riverside and the Texas A&M University Agricultural Field Station at Fort Stockton. The primary breeding objective was to develop new cultivars.

Botany

It is a woody perennial shrub of family Asteraceae, less than 135cm. in height and produce silver grey leaves. The flowers are produced in clusters in inflorescences on peduncles which extend outward in all directions from the plant. The inflorescence forms a spherical clusture containing bisexual flowers. The composite flower has female flowers along the outer ray and male flowers in the centre as well as on both sides of each female flower. Floral tillers start producing from May and continue till August in various flushes. Seed setting starts from June - July and continues till September to October. The seed unit consisted of an achene, two attached staminate florets and a subtending bract.

Guayule rubber

Rubber in the guayule plant is located in stem, root and branches in sclerenchyma cells of cortical tissues. Mehta *et al.* (1979) has identified certain

anatomical features as an indication of high rubber bearing plants. Plants having longer vascular ray fissures contain more rubber. Larger number of leaf hairs have shown positive correlation with rubber content (Healey *et al.*, 1986). Guayule rubber is similar to *Hevea* rubber in chemical composition. It is a polymer with a chain of thousands of isoprene molecules (C_5H_8) linked together. Polymers can be of 25,000 or more units. Variation of 8-26 per cent in rubber content of guayule have been observed. Naqvi and Hanson (1980) have found 19 per cent rubber content in a native population of Mexico. Tipton and Gregg (1982) observed similar rubber content in native populations of Texas.

Processing of rubber

During World War II, guayule rubber was obtained by grinding the shrub in water and skimming off the floating rubber "worms". Unfortunately, the rubber from this process contains resinous impurities that make the rubber tacky, soft and likely to break with time. Afterwards in 1970s, new procedures were developed. In the new process, resin in the worms was removed by solvent extraction. Rubber produced in this way can make high-performance aircraft tyres. Further improvement in rubber quality and efficiency of production came about with the sequential extraction procedure. The sequential process used two different solvents : one to dissolve and remove the resin and the other to dissolve and separate the rubber. The latest extraction process uses only the solvent to dissolve both the rubber and the resin. Dissolved rubber in the mixture is then removed by selective coagulation and precipitation. In the late 1980s, Bridgestone/Firestone, Inc., built a pilot facility in Arizona for extracting rubber with this process. Garrot *et al.* (1981) recommended a modified procedure by using liquid nitrogen which has been used to estimate the length of time required for drying. Freshly cut plant approximately 8 cm above the root crown has to be parboiled at 80°C for 15 minutes and then air dried for 16 minutes, chopped into lengths of 2.5- 5.0 cm and frozen in liquid nitrogen. The frozen material has to be then processed for rubber extraction.

Application of rubber and its co-products

The demand for rubber continues to grow. Natural rubber now accounts for 31.5 per cent or 4.7 million tons annually, of the total rubber market worldwide. About two-thirds of this natural rubber is used for tyres and related products. A passenger tyre is made up of 30 per cent natural rubber and aircraft tyre 100 per cent. The remaining natural rubber goes into making other rubber products such V-belts, conveyor belts, storage tank linings and hoses. A small amount is used in footwear and adhesive products.

Blending guayule rubber with polyolefins produces a polymer for making extruded or injection-molded products. Chemical modification of guayule rubber

has produced new types of polymers. These polymers have properties similar to those of existing thermoplastic elastomers for making various types of molded goods. Resin like compounds derived from the rubber extraction process add to the co-product value of the guayule shrub. The co-products of guayule consists of low-molecular-weight rubber, organic and water soluble resins and Bagasse (plant residue). These low molecular weight rubbers are used in manufacture of various polymers which serve as building blocks for making more complex compounds that are useful in industry. Epoxy compounds of low molecular weight rubber has potential in making adhesives and thermoplastic polymers. Hydroxylated compounds of this low molecular weight rubber can make polymer farming raw materials used in producing polyesters. The resin can be used as a plasticizer for other high-molecular weight polymers. Wood impregnated with organic soluble resin is resistant to attack by marine borer, termites and soil fungi. The bagasse can be converted to an important chemical raw-material for manufacturing industrial solvents, resins and plastics.

Genetics and breeding behaviour

Guayule plants are either diploid ($2n = 36$) and sexual or polyploid ($2n = 54, 72$ and higher) and facultative, apomicts (Bergner, 1946; Esau, 1944). The flowers do not require pollination to set seed. The varietal characteristics can be perpetuated through the seeds, which facilitates plantation culture. The occurrence of B-chromosomes among diploids and polyploids (Bergner, 1946; Catcheside, 1950) and the presence of a sporophytic system of self-incompatibility at the diploid level (Estilai, 1984; Gerste, 1950) further complicates genetic studies. The non-availability of easily recognizable genetic markers is also a factor.

Parthenium has 17 recognized species. Rollins (1944) described natural hybrids between *P. argentatum* and *P. incanum* H.B.K., commonly known as mariola. Rollins (1946) made crosses of guayule plants ($2n = 36$ and 72 chromosomes) with *P. tomentosum* DC and *P. stramonium* (*P. tomentosum* var. *stramonium*) both with $2n = 36$ chromosomes. These hybrids were generally intermediates between the two species with respect to leaf size, flower size, number of disc florets per head and the length of peduncles. The primary breeding objective is to develop new cultivars with a high concentration of rubber and adequate biomass to produce economically viable annual rubber yields. This can be accomplished either through interspecific hybridization between desirable diploid *Parthenium* species or by making further selections from among the existing apomictic USDA lines. The NAS report of 1977, and the articles of Thompson and Ray (1988) and Estilai and Ray (1991) have thoroughly reviewed the past and current status, development and future trends in the area of guayule germplasm collection, evaluation, enhancement, genetics and breeding. Thompson *et al.* (1988) initiated a selection programme

from germplasm held by NPGS. Dierig *et al.* (1989 a, b) evaluated selections of this population and established relationship of morphological variables of rubber production and variation among and between various selected apomictic lines. A large amount of genetic variability has been shown to exist within the facultative apomictically reproducing polyploid populations. Thompson *et al.* (1988), Dierig *et al.* (1989 a, b) and Ray *et al.* (1990) have explained the model for the role of apomixis in generating genetic diversity which can be used in further selection.

Agro-climatic requirements

High temperature does not appear to affect this plant but low temperature governs its growth and survival. It withstands temperature between -18° and 40°C in its native habitat. The growth slows down below 16°C and it becomes semi dormant at temperatures below 4°C . Exposure to frost conditions (-7°C) may injure tender plants but those induced into dormancy by gradual decline in temperature remain unaffected. It has been found to be growing in a wide variety of shallow, stony, calcarious and friable soils but the most suited is well drained sandy loam soil since it is very susceptible to water logging. Water requirements have been estimated to be 450-600 mm (NAS, 1977). Excessive vegetative growth takes place in areas having higher rainfall, more than 640 mm, but rubber is low.

Propagation

Guayule grows in a wide variety of shallow, stony, calcarious and friable soils. Annual rainfall in its native habitat is 230 to 400 mm but water requirements have been reported to be 450-600 mm (NAS, 1977). Excessive irrigations (1330 mm) in arid regions have been reported to cause faster growth, higher rubber yield and early harvesting (Bucks *et al.*, 1985). One of the major problems for Guayule propagation is poor germination due to seed dormancy. This is due to embryo dormancy of 2 months and longer lasting (6-12 months) action of seed coat. There are certain inhibitors also in the male florets which remain attached to seeds (Naqvi and Hanson, 1980). Treatment of new seeds for two hours with a solution of equal parts of 200 ppm GA 3 and 1.0 per cent NaOCl after soaking in distilled water for 8 hours have been reported to result in high germination percentage on fresh seeds (McCallum, 1929; Naqvi and Hanson, 1980). Chandra (1991) reported that osmo conditioning improves seed quality for germination. Seeds treated with polyethylene glycol (MW 8000) and 100 μm gibberelic acid have shown more than 90 per cent germination. Seed size and depth of seeding have also been reported to affect seedling emergence. Emergence percentage is decreased constantly with increase in depth of seeding when seeding was done from surface to 18mm below

surface. About 500 g seeds is enough for raising a nursery for one hectare plantation. For this purpose, a raised nursery bed of 1.25 × 1.20 m size is required. In the nursery, plants need to be hand watered and irrigated twice a day till two weeks before transplanting and weeding is required twice a week.

Direct seeding has not been successful because of the small seed size, low and variable seed germination rates, low seedling survival, and weed competition. (Fangmeier *et al.*, 1994; Hammond and Polhamus, 1965). As a result guayule fields are established by transplanting atleast 8 weeks old seedlings that had been raised in green houses. Nursery raised seedlings are ready for transplanting about 6-8 weeks after sowing and the month of April has been identified as the best time for transplanting of Guayule in field under north Indian conditions. (Bhag Mal *et al.*, 1994). These seedlings should be transplanted at a row to row spacing of 60-75 cm and plant to plant spacing of 45 cm so as to obtain plant population of 30,000 to 55,000 plants/ha depending upon the growth habit of genotype and availability of water. Establishment of seedlings is a difficult and costly task. Severe losses are encountered during transplanting, unless the seedlings are induced into near dormant state by cold or drought. For this purpose, irrigation to the nursery is stopped two weeks prior to transplanting. Immediately after transplanting, the seedlings are furrow irrigated and light/sprinkler irrigations are given twice a week for the next two weeks and once a week for the succeeding five weeks (Bucks *et al.*, 1985). Once the plants are well established, not much irrigation is required in the semi-arid regions. However, irrigation is important from the point of view of cutting down the life for economic harvest from 5-8 years under rainfed conditions to 3-5 years under irrigated conditions (Bucks *et al.*, 1985). For north- west Indian conditions, it was observed that one flood irrigation per month during spring-summer (March-June) coupled with rains during July to September induced good growth. Withholding irrigation during winter could induce dormancy and force rubber formation to facilitate harvest towards the end of winter season. It was reported that high irrigation encouraged biomass production but rubber concentration remained low. (Hammond and Polhamus, 1965). High rubber yields could be achieved by alternating long periods of low and high water stress. Trends towards higher rubber percentages were obtained after frequent and moderate periods of stress in the growth cycle. (Retzer and Mogen, 1947). Although maximum production of rubber require large quantities of water (Miyamoto and Bucks, 1985), the efficiency of water use, that is, rubber yield per unit of irrigation water, is actually higher under high stress conditions (Miyamoto *et al.*, 1984). Thus in places where water shortage prevails, growing guayule under low irrigation could be commercially advantageous.

As rubber in the plant is contained in stem, root and branches, the whole

plant is normally dug out for rubber extraction. Bucks *et al.* (1985) have suggested that only above ground portion (5 cm above ground) should be clipped for harvesting, to allow regeneration from the roots left in the ground. This method is called pollarding or coppicing. Most roots have been reported to regenerate and grow into new shrubs so fast that a one year old pollarded guayule bush becomes as large as a two year old seedling. In principle, this method rapidly produces two crops while avoiding the expensive replanting normally required. Under rainfed conditions of arid/semi-arid regions, 5-8 years are required to bring to economic harvest. This duration can be reduced to 3-5 years by enhancing growth rate with the help of supplemental irrigation,

Time (season) of harvest depends upon rainfall distribution and prevailing temperatures as it has a peculiar need for induction of semi-dormant state to be able to accumulate rubber. The highest amount of resin and rubber have been reported to occur at the end of the dormancy period (NAS, 1977). Under the north-west Indian conditions, this is in late February and March.

Research work under coordinated research programme

Agronomic and genetic research has been initiated to increase rubber production. Twenty three germplasm lines assembled from different countries were evaluated at the NBPGR Research Farm at Isapur for various agro-morphological traits and the promising types with high biomass production potential were identified which were tested at different locations under the coordinated programme. Based on multi-locational testing, HG 8, the most promising one was released in 1991 for general cultivation in arid and semi-arid regions of the country. This variety contains 6-7 per cent rubber and produced 10 q/ha raw rubber under Hisar conditions.

Chemical analysis revealed that rubber content varied from 3.4-7.00 per cent while the resin content varied from 4.69-6.25 per cent. Studies conducted at monthly intervals at Delhi indicated that the best time for raising the nursery under north-west Indian conditions was February. (Bhag Mal *et al.*, 1994).

Agronomic studies conducted showed 60 cm to be the optimum spacing between rows and 45 cm between plants. Fertilizers application of 40 kg N and 30 kg P for first year and 20 kg N in second year is congenial for good growth of Guayule. Irrigation during March-June induced good growth.

At HAU, Hisar, ten genotypes were studied for twelve quantitative characters. Analysis of variance showed significant variability and potential for improvement through breeding. (Chhabra *et al.*, 1990). Rubber yield exhibited significant positive correlations with plant circumference, basal branches per plant, and fresh and dry shrub yield per plant. Therefore, direct selection for number of basal branches per plant and plant diameter can be made to get plants having higher rubber production.

CONCLUSION

Low rubber yield of the available germplasm and the high cost of growing and processing the shrub, as well as the need for high capital investment for the construction of processing plants are considered major hurdles in guayule commercialization. (NAS, 1977; Estilai, 1987; Thompson, 1989). Farmers don't grow the crop because the rubber processing facility is not available and industry do not build the facility because of the lack of a reliable source of the shrub. Therefore, some special incentives and subsidies from government agencies should be given to the farmers and industrialists to encourage guayule cultivation and commercialization respectively. And this is the right time for it, because producers are willing to experiment with something new which produces a raw material of significant industrial importance, and also the stand crops are no longer profitable with subsidy.

Guayule has great potential to become an important source of natural rubber. Increasing the yield, decreasing the production costs and finding new products of guayule will improve and hasten its chance for commercialization. Since abundant area in India, are lying uncultivated in arid and semi-arid marginal lands in parts of Rajasthan, Gujarat, Haryana, Punjab, Maharashtra and Tamil Nadu states, guayule holds a great promise of increasing production of natural rubber (Paroda, 1979). The promising varieties available should be multiplied at 2 or 3 centres. The best identified varieties should be tested under mini-kit trial on large scale in collaboration with the forest and agriculture departments in different states.

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ETHNO-MEDICO-BOTANICAL ENUMERATIONS FROM PATALKOT VALLEY IN CHHINDWARA DISTRICT OF MADHYA PRADESH

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Key words : Patalkot valley, Bharia tribe, ethno-medico-botanical survey

The state of Madhya Pradesh has the largest concentration of tribal people in the country. Chhindwara district (680m above msl) is situated on Satpura plateau and lies between 18° 9' - 20° 9'N and 78°10' E respectively. Patalkot is situated on the slopes of Satpura mountains in the north-west corner of Chhindwara district. Nature has artistically carved out the deep valley amidst lofty mountain walls. It is like a fort in the subterranean, as is signified by the name Patalkot (Patal - subterrene, Kot- fort). The valley is located at about 60 km away from Chhindwara and is flanked by three mountain wings of Satpura range. It seems that the earth itself has sunken, encircling 20 villages, of which three are deserted. The Bharias, a little known tribe of valley utilize a large number of plant species occurring wild, as herbal remedies in various diseases and ailments. Earlier ethno-medicinal uses of plants in Madhya Pradesh were reported by Jain (1963, 1965), Saxena and Shukla (1971), Umesh Chandra and Mehra (1983), Maheshwari and Dwivedi (1988) and Umesh Chandra (1991). The present study, based on information gathered during an ethno-medico-botanical survey conducted in tribal villages of Patalkot valley, which is mainly inhabited by Bharia tribe, in November 1991, reveals ethnic uses of plants and plant parts in different kinds of ailments which is enumerated below :

Sequence : Botanical name, Vernacular name (if any), family (in bracket), uses/folklore, name of village.

Achyranthus aspera; Latzeera, (Amaranthaceae). Seed powder when taken for one week, it helps in curing bleeding piles. Rater.

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Adina cordifolia (Roxb.) Benthum & Hooker f. ex Brandis; Haldu, (Rubiaceae). Leaf juice is used to kill worms in sores. Pachgol.

Aegle marmalos (L) Correa; Bel, (Rutaceae). Green fruit powder when taken in water twice a day for six weeks, dysentery is cured. Also bark decoction is taken thrice a day for one week in intermittent fever. Chintipur.

Aerva lanata (L) Juss.; Chilarbhaji, (Amaranthaceae). The root paste when rubbed on forehead, relief in headache is experienced. Rater.

Allium cepa L.; Piya, (Liliaceae). Juice of the bulb with honey is used in cholera. Karpapani.

Alstonia scholaris R. Br.; Chatwa, Saptaparna, (Apocynaceae). Bark decoction when taken thrice a day for one week, malarial fever and dysentery are cured. Pachgol.

Amaranthus tricolor L.; Matabhaji (Amaranthaceae). Decoction of root cures ulcer of throat when taken twice a day for one week. Rater.

Argemone maxicana L.; Bharghara, (Papaveraceae). For healing wounds, the juice of stem is used twice a day for one week. Chhindi.

Aristolochia indica L.; (Aristolochiaceae). Root paste is applied as antidote in venomous insect bite. Jhiran.

Barleria prionites L.; Kantaphul, (Acanthaceae). Root and leaf paste is applied to disperse boils and glandular swellings. Chintipur.

Bauhinia variegata L.; Mohla, (Caesalpinaceae). The flower powder is used three times a day in haemorrhage, bark powder cures skin diseases. Chintipur.

Blumea lacera (Burm. f.) DC; Kukrondha, (Asteraceae). Plant juice is used to cure bleeding piles and diarrhoea. Sukhaband.

Bombax ceiba L.; Semal, (Bombacaceae). Resin powder is used thrice a day to cure diarrhoea. Chintipur.

Cassytha filiformis L.; (Lauraceae). Stem is powdered and mixed with *Sesamum* oil, it is used as hair tonic. Karpapani.

Chlorophytum arundinaceum Baker; Safed musli, (Liliaceae). The tuber is boiled with milk and is taken twice a day in cases of impotency. Chintipur.

Hordeum vulgare L.; Jau, (Poaceae). Parched and powdered grain is employed in the form of gruel in case of painful and atonic dyspepsia. Harrakachar.

Laggera alata Schulz.; Sanpbuti, (Asteraceae). The leaf and root powder is taken thrice a day for one week in snakebite. Malni.

Leucas aspera (Willd.) Spreng.; (Lamiaceae). Flower with honey cures cough and cold in children; leaf juice is useful in skin eruption and painful swellings. Rater.

Mitrgyna parviflora (Roxb.) Korth.; Mundi, (Rubiaceae). Bark and roots for fever and colic pains. Jhiran.

Opuntia stricta var. *dillenii* (Ker.-Gawl.) Benson; (Cactaceae). Baked fruits are used in whooping cough, stem-joints paste in water as poultice in inflammation of joints; the paste when applied to boils, it hastens suppuration. Rater.

Pergularia daemia (Forsk.) Chiov.; (Asclepiadaceae). Leaf juice is useful in controlling excessive bleeding disorder. Dubba.

Phragmites karka (Retz.) Trin. ex Steud.; (Poaceae). Root paste is useful in fractured bone. Rater.

Polygonum glabratum Willd.; (Polygonaceae). Herb extract when taken thrice a day, pneumonia is cured. Rootstock is used to cure piles. Pachgol.

Ricinus communis L.; Arandi, Rendi, (Euphorbiaceae). Root paste is useful in curing eczema, skin diseases. Malni.

Rivea hypocrateriformis (Desr.) Choisy; Roots when inserted in vagina during childbirth, it cleans the womb. Karrapani.

Swertia angustifolia Buch. Ham. ex. D. Don; Chirayata (Gentianeae). Plant decoction is used as tonic. It cures stomach disorder also. Harrakachhar.

Tectona grandis L.; Sagaun, (Verbanaceae). Wood extract is applied on swellings, wood ash in swollen eyelids. Chhindi.

Tylophora indica (Burm. f.) Merrill; Antamul, (Asclepiadaceae). Roots and leaves are used in treatment of dysentery, asthma and bronchitis. Rater.

Vitex peduncularis Wall. ex Schauer; Nagbail, (Verbanaceae). Bark paste is applied externally in chest pain, leaf infusion is used to cure malaria. Karrapani.

Zizyphus mauritiana Lamk.; Ber, (Rhamnaceae). Fruits have cooling effect, pulp is used as poultice in hard boils. Sukhaband.

Zea mays L. Sp.; Makka, (Poaceae). Grains nutritive, cooling. Chimtipur.

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SORGHUM STAPFII (HOOK.F.) C.E.C. FISHER— A LITTLE KNOWN WILD SPECIES FROM TAMIL NADU

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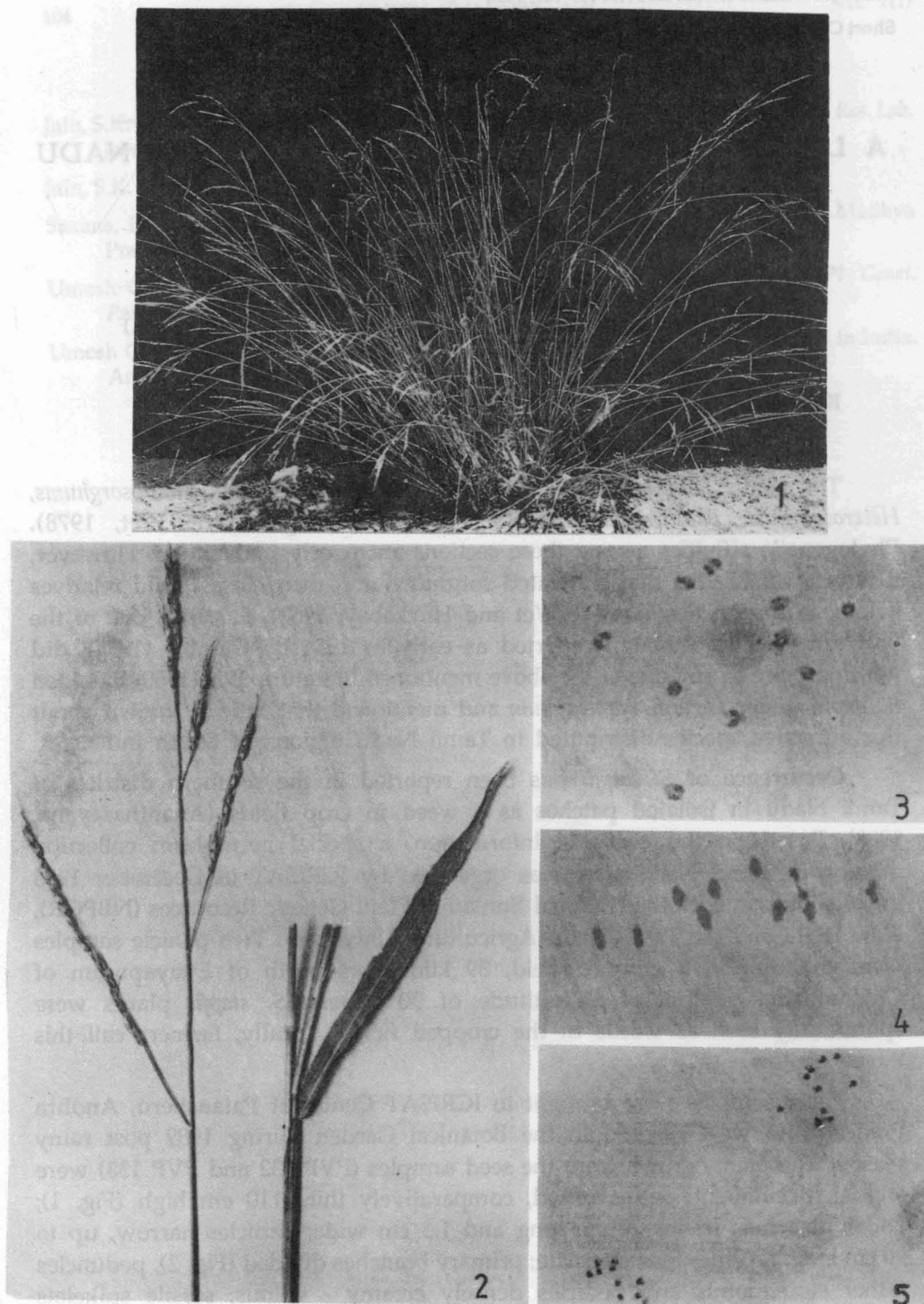
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Key words : *Sorghum stapfii*, occurrence, systematics

The genus *Sorghum* Moench is subdivided into sections *Chaetosorghums*, *Heterosorghum*, *Parasorghum*, *Stiposorghum* and *Sorghum* (de Wet, 1978). Phylogenetic affinities among these sections are poorly understood. However, it is well established that cultivated sorghums and their closest wild relatives belong to section *Sorghum* (de Wet and Huckabay, 1967). *S. stapfii*, one of the *Sorghum* species although reported as early as 1934 by Gamble (1934), did not find place in any one of the above mentioned literature. Bor (1960) included *S. stapfii* under section *Parasorghum* and mentioned that little is known about this attractive species distributed in Tamil Nadu region of South India.

Occurrence of *S. stapfii* has been reported in the southern districts of Tamil Nadu in isolated patches as a weed in crop fields (Ananthasayana, 1983). Based on the available information, a special germplasm collection mission in Tamil Nadu state was organised by ICRISAT in December 1988 in collaboration with the National Bureau of Plant Genetic Resources (NBPGR), New Delhi and the Tamil Nadu Agricultural University. Two panicle samples were collected in a cropped field, 39 kilometers north of Ettayapuram of Chidambaram district at an altitude of 30 meters. *S. stapfii* plants were sporadically seen as weeds in the cropped fields. Locally, farmers call this Payee cholam.

These samples were brought to ICRISAT Center at Patancheru, Andhra Pradesh and were planted in the Botanical Garden during 1989 post rainy season. The plants grown from the seed samples (PVP 132 and PVP 133) were annual, decumbent; culms tufted, comparatively thin, 110 cm high (Fig. 1); nodes glabrous; leaves 20 cm long and 1.5 cm wide; panicles narrow, up to 20 cm long, racemes few, alternate; primary branches divided (Fig. 2), peduncles rather stout; joints and pedicles densely creamy - villous; sessile spikelets



Figs. 1-5. Morphological and cytological features of *Sorghum stapfii* ($2n = 20$) : 1) growth habit, 2) panicle branching and glabrous sheath nodes, 3) diakinesis, 4 metaphase 1, and 5) anaphase 1.

conspicuously large in size around 7.0 mm long and 3.0 mm wide, ovate-lanceolate, densely tomentose; glumes of sessile spikelets very coriaceous, tomentose on the back; awns 2.6 cm long, pedicelled spikelet linear to lanceolate, 6 mm long and 1 mm wide, mostly sterile and smaller than sessile spikelet. They were identified as *Sorghum stapfii* by their distinguishing morphological characters discussed above.

Meiosis was studied in pollen mother cells (PMCs). Young inflorescences were fixed Carnoy's solution for 24 h, and anthers dissected out from spikelets were squashed in 1 per cent acetocarmine stain. The species was found to be a diploid, with a chromosome number $2n = 20$ ($n = 10$) (Fig. 3-5), which confirms the earlier report of Ananthasayana (1983). Regular formation of 10 bivalents was seen in the PMCs and a majority of the cells have one nucleolus with a bivalent attached to it. However, PMCs with more nucleoli were found occasionally. Anaphase I and subsequent stages of meiosis were normal, and pollen fertility determined by stainability with acetocarmine was found to be 61 per cent.

The glabrous sheath nodes, divided primary branches and $2n = 20$ chromosome number of *S. stapfii* suggest that it does not belong to the section *Parasorghum* as reported by Bor (1960). The morphological and cytological characters observed in the present study indicate that *S. stapfii* is a member of the section *Sorghum*. This change of classifications is further strengthened from the findings of Ananthasayana (1983) who was able to cross *S. stapfii* with *S. nervosum*, another species with $2n = 20$ chromosomes belonging to the section *Sorghum* (de Wet, 1978). The seed of *S. stapfii* is conserved in the Gene Bank of Genetic Resources Division at ICRISAT Asia Center, Patancheru, alongwith the herbarium specimens.

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SOLANUM GILO RADDI — A LESS KNOWN VEGETABLE OF NORTH-EASTERN INDIA

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Key words : *Solanum gilo*, occurrence/distribution, botany, nutritional value

The family Solanaceae has provided about 185 edible plants and 40 cultivated and 18 commercially grown crops (Harlan, 1975) which have contributed much to the human nutrition the world over. In India, the north-eastern region is the home for several solanaceous plants. It is estimated that atleast 35 species belonging to family Solanaceae occur in the region (Rao, 1982). Out of these, 15-16 species are consumed as vegetable by the inhabitants, particularly by tribal population. Important but less known edible species among these are - tree tomato (*Cyphomandra betacea* (Cav.) Sendt., *Solanum torvum* Sw., *S. indicum* L., *S. integrifolium* Poir., *S. kurzii* Br., *S. spirale* Roxb., *S. barbisetum* Nees, *S. macrocarpon* L., *S. xanthocarpum* Schrad. & Wendl., *S. straminifolium* Jacq. (= *S. ferox* Clarke) and *S. gilo* Raddi.

Among various solanaceous vegetables, the fruits of *Solanum gilo*, *S. integrifolium* and *S. torvum* inspite of their bitter taste, are boiled, cooked and consumed as vegetable with rice. (Arora and Hardas, 1977). *S. gilo* is important among these as it is grown in the kitchen garden by tribals of NE Region. Still no published report is available on the nutritional value of this species. This communication is an attempt to throw light on distribution, botanical plant characters, nutritional value as well as other related information on *Solanum gilo*.

During survey undertaken in NE states from 1986 to 1992 for the collection of genetic resources of agri-horticultural crops, 65 accessions of *Solanum gilo* were sampled. Out of these, 30 accessions were grown at NBPGR Experimental Farm, Barapani, Meghalaya and the rest were supplied to the Gene Bank at NBPGR, New Delhi. Various plant and fruit characters were recorded to depict

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the botanical characters in details. The unripe fruits were collected, dried at 40-50°C in the slice form and were used to determine the nutritional value following the methods given by Nicholas and Nason (1957), Bailey (1967), Wistler (1962-71), Kates (1972), and Swain *et al.* (1979).

The bitter brinjal (*S. gilo*) is a prized vegetable particularly of Khasi and Mizo tribals. *Solanum gilo* Raddi. - a small thornless shrub growing up to 150 cm height stem with 4-5 branches and petioles are adpressedly pubescent. Petiole 2.5 to 3.0 cm long, leaf oblique, lobed (3 on left and 2 on right half of lamina), mid rib and secondary nerves raised on lower surface; apex acute, upper surface green and lower whitish, glabrescent, of size 15-20 cm long x 10-12 cm wide. Inflorescence axillary, 3-flowers at each node; flower white, gamopetalous at base, calyx-5, whitish, firmly attached. Fruit peduncled, peduncle 2.0 to 2.5 cm, globose, smooth or grooved, greenish-yellow shining or pale-green 2.5 to 3.0 cm in diameter and on ripening turns golden yellow or orange red; 4-locular, centre pithy, flesh less juicy and bitter. Seeds kidney shaped, smooth, surface white, creamy or brown.

The taxonomic confusion and nomenclature complexities had prevailed for long to reveal relationship between cultivated and related wild species of brinjal. Recently Lester *et al.* (1990) made large collection from the African countries and on the basis of *inter se* crossability classified them under *Solanum aetheopicum* L. and remarked that they must have been derived from *S. anguivi* Lam. (= *S. indicum* auct. non L). According to him *Solanum aetheopicum* L. contains four groups viz., *Aculeatum*, *Gilo*, *Shum* and *Kumba*. The species *S. gilo* Raddi. was included under *S. aetheopicum* L. (*Gilo* group). The fruits in *S. aetheopicum* (*Kumba* group) are bigger and have more locules and no star-hair pubescence. Young leafy tops and green immature fruits are cooked as vegetable. Similarly, *Shum* group (= *S. zuccagnianum* Dun.) have small glabrous leaves and small fruits and are not grown extensively. The group *Aculeatum* is found in Europe and have bitter, multilocular fruits.

In NE India, the wide occurrence of this and other related species, especially *S. indicum* L. is suggestive of an independent evolution and domestication of *S. gilo* in the region. More so, in the absence of any evidence for its introduction across the country. The species is being grown in hilly areas of Meghalaya, Mizoram, Arunachal Pradesh, Assam, Tripura and Nagaland. The tribals of these states consume the immature green fruits which is bitter in taste. In African countries, these bitter fruits are liked for flavour and are believed to confer various medicinal properties such as prevention of malaria or increasing lactation (Lester *et al.*, 1990).

The analysis of nutritive value of green fruits of bitter brinjal (Scarlet brinjal) on dry weight basis gave the following results - moisture 28 per cent; protein 5 per cent; total sugar 13 per cent; starch 4 per cent; free amino acids

0.92 per cent; phenolics 2.8 per cent. The green fruits of *S. gilo* are a good source of protein. The high phenolics content is beneficial in the diet as they are known to minimise the toxicity and also have antiseptic and bacteriastatic action and regulate the pH in the intestine (West *et al.*, 1966).

The *S. aethiopicum* (*Gilo* group) can withstand adverse weather and irrigation and is less prone to insect and fungal attack. This character could be profitably used to evolve hardy brinjal varieties. Moreover, other taxa such as *S. indicum*, *S. aethiopicum*, *S. integrifolium*, *S. olivare* are closely related to *S. melongena* (Pearce and Lester, 1979), and, therefore, transfer of useful genes will be simple and easy. Further research is required to reveal more about the usefulness of this vegetable in tribal diet. There is also need to improve it genetically and to work out better cultural practices, for its large scale cultivation.

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COLLECTING RICE GERMPLASM IN BIHAR

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Key words : *Oryza sativa*, germplasm collection, landraces

Rice in Bihar is a staple food and cultivated in different ecosystems. The genetic erosion to natural plant genetic resources in rainfed ecosystem is minimal whereas landraces/primitive cultivars in irrigated ecosystem have been wiped out and replaced by the modern semi-dwarf high yielding varieties of rice. To avoid further genetic erosion, explorations were undertaken to collect in the parts of Bihar and adjoining areas. The rice germplasm was also collected from these areas alongwith other crop specific explorations. Each landrace in rice was represented by its vernacular name and was distinguishable from other landraces. It was observed during the explorations that sometimes two different landraces had the same vernacular name but were phenotypically different. Till date, a total of 452 seed samples of paddy were collected from 195 sites of Bihar but much of the areas still remain to be explored and many more genotypes are to be collected.

The genetic diversity of rice (*Oryza sativa* L.) has been shaped by its early place in human nutrition, its subsequent dispersal to the world most geographically and culturally diverse region from Nepal to Vietnam (Chang, 1976). Rice feeds the people more than any other crop in the world. Rice is grown in about 90 countries spread over six continents and has diverse agroclimatic situations ranging from upland to maximum water depth of six meters in India especially in Bihar.

In Bihar, rice is mainly cultivated under four ecosystems viz., upland, rainfed lowland, irrigated and deepwater. In rainfed areas, indigenous landraces still occur and are adapted to a particular type of ecosystem in the course of evolution. Modern rice varieties have very little impact in rainfed areas owing to their nonadaptability to such environments. Hence, genetic erosion in rainfed

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ecosystem is minimum. The valuable genepool of rainfed areas could be useful source for resistance/tolerance to biotic and abiotic stresses prevalent in Bihar. According to Paroda and Malik (1990), about 50,000 landraces of rice are expected to exist in India. Considering the national and state collections together, a total of nearly 66,000 cultivars have so far been collected (Sharma and Hore, 1990) of which about 50 per cent may be duplicates. Thus, about 17,000 landraces of rice still remains to be collected in the country including from some areas of Bihar which show tremendous genetic variability in the form of landraces. In view of this, exploration and collection programmes were undertaken in Bihar.

Germplasm collection

Eight explorations (1988 to 1993) (Table 1) were conducted to collect the germplasm of paddy and its wild relatives from Bihar. During 1992, a crop-specific mission for rice was carried out jointly by NBPGR and IRRI to collect the wild relatives of *Oryza sativa*. Each landrace in rice is represented by its vernacular name and easily distinguishable from other landrace. These landraces mostly had tall plant type, lax panicles and pigmentation in different plant parts but had resistance tolerance to the different diseases and pests. The important landraces collected from each district are presented in this paper.

A total of 452 landraces of rice were collected from Bihar. Each landrace was given Accession number (NIC No.) by NBPGR and classified districtwise.

Table 1 : Details of areas explored

Period	Areas explored	No. of sites explored	No. of sample collected
October 1988	Ranchi, Vaishali and Hazaribagh	3	4
December 1989	Palamau, Ranchi, Hazaribagh, Gaya, Varanasi and Aurangabad	33	86
Dec 89-Jan 90	Lohardaga, Palamau, Gumla, Ranchi, Singhbhum and Hazaribagh	58	164
Nov.-Dec. 1990	Bhagalpur, Katihar, Purnia, Madhepura and Saharsa	38	110
Sept. - Oct. 1991	Ranchi, Santhal Pargana, Dumka, Sahibganj, Godda, Giridih, Gumla, Singhbhum and Palamau	49	68
Sept. - Oct. 1993	Ranchi, Hazaribagh, Nalanda, Muzaffarpur, Darbhanga	14	20

Ranchi - A total of 94 accessions were collected from the farmers fields. These are Chhotagora, Badagora, Dhusari, Hathipanger, Rosedhan, Thakurprasad, Ciabir sall, Samleig, Comlei, Sikki, Kalamdanimotta, Kalamdani lal, Barkadhan, Chhotadhan, Jasar, Jaidhan, Dahiya, RaniKajal, Karhani, Serikell, Damur, Tilasar, Doriah, Chota Dahiya, Bara Dahiya, Shyamjeera, Laxmibilai, Kalamdani, Bhogni, Aujani, Pangerbhag, Nata, Bhudhan, Charak, Tulsimohan, Gopalbhog, Laldhan, Blackgora, Kanau, Sathi, Goradhan, Locura, Dhanigora, Tamlaka, Blackgora, Karhani, Browngora, Konnai, Dhanigora, Kanigora, Charkagora, Dhudhigora, Chaingora, Bachakarmi and Asanloiya.

Gaya - From the 4 villages of the district, 6 accessions were collected which include Sherma, 458, Ambagoudi, Dudhibilas.

Hazaribagh - Fifty one accessions collected included Deiou, Laldhan, Harkolia, Lakhansal, Dhusari, Lakhanpal, Jonga, Pathri, Syamjeera, Devata bhog, Kairasal, Balbhog, Oudhkari, Ranikajal, Chandrakanda, Kalamalau, Jonga, Beshphoo, Hastkalma, Chandragahi, Rasgol, Karikakochi, Dudhkalma, Nardha, Dutwa, Jhuna, Bangla, Raigoli, Askalma, Karanga, Bhura, Karanga kala, Laldulara, Badrash, Sidwa, Ketka, Shyam jeera, Nandhi, Jhingasar, Kardhani, Jonga, Kalam dhan, Satal chini, Gora dhan, Browngora, Karhani dhan, Chhotagora and Badka gora.

Palamau - Forty six accessions were collected which include Chaingora, Baberi dhan, Kabirwa, Kawari, Pandi, Lalka, Tilasar, Karhani, Kalamdani, Karhani(Red), Ceajpatti, Jhingasaar, Haldigudi, Tasnamarba, Jarhan, Bhatuasain, Hardiphool, Jhungisaal, kalagora, Danigora, China gora, Minustwo, Sonachur, Lohasingh, Kalajeera, Bhurakabeer, Basfool, Badshah Bhog and Shyamjeera.

Lohardaga - Dehia, Bhangani, Gora dhan, Kalamdhani, Katuki, Thosar, Tamriya and Dhani.

Gumla - Bhajani, Kabhiphool, Baccha, Kalamdani, Dusari, Karmusain, Laldhan, Gordhan, Biyagora, Ponnaigora, Karangagora, Choottadhan and Dudhi gora.

Singhbhum - Ninety four accessions collected included Bhogna, Lakhansali, Dudhkalma, Gayaballi, Kalabhagha, Laloughisari, Birada, Ramsaal, Gahudhah, Saldhan, Laldhan, Sitasall, Satbhuiya, Goyan, Juguri, Budadhan, Basmati, Jarli, Satboil, Kakri, Rajamai, Nanika, Marto, Bhogna, Bhari, Gora, Gora, Malti, Halka, Bhogna, Bara Bhogha, Tabur Rai, Ajon dholi, Asbhonga, Jhingersall, Kasiphool, Baramalta, Billmalta, Deepti sall, Dhoba Bhogna, Billdhan, Dudhmalai, Manjhidhan, Assamloya, Bibisall, Goya balli, Radhakanka, Dhanijeera, Sonakate, Azam dulla, Bilaity Bhonga, Manik kalam, Dudhsar, Malti, Chingrichopa, Maghi, Patny, Samunderdhan, Chanderkanti,

Bheemsall, Makerkand, Jhingasall, Bhungi (Red), Malta, Motta Phusani, Thuppsel, Sutalsall, Bhomar malli, Surumalli, Badna mal Kalam Kadhi, Kashiphool, Nahnigora, Alsangagora and Chigurigora.

Bhagalpur - Singhara, Baraber and Panikala.

Katihar - Karkaamon, Kajargora, Bhatni, Pansera, Khera dhan, Chanan chur, Kari kamod, Kaniyal, Panjhali, Bhorwa, Kusumsar, Paghli, Amachhor, Kanak jeera, 436, Basphool, Salmot, Masuri yaman, Kamod, Barogar, Bhatni, Pansera, Uttwa, Risal dhan, Kerma, Kejargur, 26 no., Katiksar, Dama Kanjal, Ballore, Singhra, Ajgara, Changul, Sugapankhi, Sonakari, Deba, Bhatindi, Amad and Dossa.

Purnia - Vishwamania, Bhorwa, Desi Basmati, Bhattu, Panjhali, Kajargaur, Bhatigri, Sukhapankhi, Jaswah, Malida, Lalsateria, Gahuva, Ramdulari, Bolkianazir, Dhussehera, Lalsir, Nazir, Shukla, Ratnananjuri, Basmati, Khera, 26 no., Gotta, Bhesa lottan, Motta, Kalam, Bachi, Simda, Purndha, Aggadda, Sanjeera, Sonapuri, Hadiford, Mahim Kerma, Malbhagia, Gakhulsar, Balam, Parva pankhi, Hathsaal, Marwadangi, Mausera, Lohagarh, Aman, Chamanchur, Harda, Bacchi, Pansera, Beshalotan, Rajwa, Kasandhan, Jayaaghani and Sureba.

Madhepura - Chanachur, Bakka, Pakher, Satkarma, Sobha, Babbe, Maheshlot and Manipuri.

Dumka - Sania, Karhani, Savania, Lungibhai and Charkhadhan.

Godda - Three accessions included Lalka bhada, Asna bhada and Bodhdu.

Giridih - Three accessions were Bhada dhan, Sathi and Bhadoia.

Darbhanga - From one village, three accession were collected. These were 1626, Lalka and Chunadhatli.

Sahibganj - Two accessions were collected.

Besides these, Bhadvi, 458, Sathidhan, Hadifore, Sawan dhan were also collected from district Munger, Nalanda, Muzzaffarpur, Saharsa, Santhal Pargana, respectively.

The maturity period of rice landraces varies from 60 days (Sathi) to more than 250 days (Photosensitive, deep water rices). Based on maturity period, these landraces were classified as very early (upto 100 days), early (101 to 115 days), medium (116 to 150 days) and late maturing types (more than 150 days). It is extremely difficult to collect all the landraces at a time because of varied maturity period. All the available landraces of rice could not be collected and most of the areas in Bihar remained unexplored. The areas thoroughly explored included north eastern parts of Bihar. More explorations at different time intervals are required to be taken to collect the existing landraces especially in central and western Bihar. The explorations

for medium to late maturing landraces are also to be taken up in the plateau region. Further, a systematic evaluation is needed to characterize these germplasm collections to differentiate between accessions with identical names; identifying accessions having the desired characteristics like resistance/tolerance to the biotic and abiotic factors and to develop the interrelationships between or among traits and between geographic groups of cultivars for an efficient use of germplasm on crop improvement programmes.

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GENETIC DIVERGENCE IN INDIGENOUS COLLECTION OF GRAIN AMARANTH

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Key words : Amaranths, genetic divergence, variance studies

Grain amaranth (*Amaranthus* sps.) is grown along the entire range of Himalayas from Kashmir to Bhutan and to some extent in the southern hills of India as a minor grain crop. Grain amaranth promises to be a crop of great potential both for its high nutritive value and its adaptability to semi-arid tracts, which forms a major portion of our agricultural lands. To initiate the crop breeding programme on sound and rational basis, knowledge on existing genetic diversity in the germplasm collection is needed. A broad spectrum of variability in segregating generation can be obtained by crossing genetically diverse parents.

One hundred and forty-four genotypes were chosen from large number of collections maintained at All India Coordinated Research Project on Under Utilized and Under-Exploited Plants, University of Agricultural Sciences, Bangalore. The experiment was laid out in the month of November, 1990 in a simple lattice design with two replications following the procedures given by Cochran and Cox (1957). All the agronomic practices of the region were adopted during the entire cropping season. Observations on eleven quantitative characters viz., plant height, days to 50 per cent flowering, days to maturity, inflorescence length, stem girth at collar region, number of branches, number of rachis, fresh weight of the plant, fresh weight of inflorescence, dry weight of the stem and grain yield were recorded on ten random plants. For estimation of genetic divergence, D^2 statistic (Mahalanobis, 1936) was used. The cluster formation was done by Dendrogram technique (Sneath and Sokal, 1973).

The analysis of variance showed significant differences among the strains for all characters. The 144 genotypes were grouped into 10 clusters (Table 1). Cluster II was the biggest having 124 entries followed by the cluster III which had 12 entries. The clusters IV (SDI-66), IX (IC 35380) and X (Annapurna)

were found to be superior with respect to yield and other yield traits. The genotypes IC 35380 and Annapurna showed highest dissimilarity and the genotypes IC 35406 and IC 35422 showed least dissimilarity.

The characters contributing maximum to the D^2 values are given greater emphasis for deciding on the clusters for the purpose of further selection and choice of parents for hybridization and generation of large variability. The highest contributor, in this regard, was fresh weight of the plant followed by fresh weight of the inflorescence (Table 2). This offers ample scope for

Table 1. The D^2 clusters and the entries included

Cluster number	Total accessions	Accession number
1	2	3
I	1	IC 35553
II	124	VDV-4/45, IC 35469, IC 35735, IC 35454 T 89-13, IC 35472, IC 35481, IC35438 IC 35604, EC 1493, V- 1989, IC 35389 IC 35465, IC 35443, IC 35551, DPP/3/50 IC 35470, IC 35518, DPP/2/29, NKG-88/42-1 DPP/3/38, IC 35461, BDJ-1-847, IC 35426 IC 35468, IC 35463, V-2008, SDI 193 IC 35406, IC 35781, IC 35479, IC 35422 BDJ-1-459, DPP/2/46, IC 35712, IC 35476 IC 35452, IC 35408A, IC 35477, IC35395 IC 35499, IC 35556, IC 35568, IC 35539 IC 21796, IC 35565, IC 35455, T-66-49 IC 21930, IC 35430, IC 35632, IC 35440 T-98-34, IC35638, SDI-93, IC 35445 DO-673, IC 21964, BD/NKG-108, IC35736 IC 42256, BDJ-1-520, BDJ-1-635, IC35440 BDJ/NNG-62, V-217, BDJ-1/962, N-955 IC 21796A, AO-941, P-57, BDJ/NKG-253 BDJ/NKG-6, P-63, IC 35411, SDI- 291 IC 35672, IC 35766, IC 35755, SDI-280 IC 35577, IC 35741, IC 35684, IC 35473 IC 35570, IC35574, IC 35415, IC 5564

	IC 35421, VDV-3/89/71, T-59-14, IC 35385
	IC 35193, IC 35410, V-1958, IC 35559
	IC 35742, IC 35706, IC 35579, IC 35653
	IC 35696, IC 35505, BDJ/NKG-388, BDJ-11-74
	BDJ-364, BDJ/NKG-145, BDJ/NKG-382
	BDJ/NKG-241, BDJ/NKG-341, C-1643
	KPS/88/176, IC 35546, C-1723, IC35659
	BDJ/89/384, BDJ/89/364, NKG/88/42-5
	IC 35450, BDJ/NKG-322A, BDJ/NKG-149
	V-2046, IC 42293, IC 35364
III	12 IC 35397, T-89-12, IC 35564, DPP/2/20, U110
	VDV3/89-46, IC 35399, IC 35496, IC 35447
	IC 35655, IC 35436, SD2-52,
V	IC 35552,
IV	SDI-66
VI	SDI-85
VII	IC 32181
VIII	IC35572
IX	IC 35380
X	Annapurna

Table 2. The two canonical vectors

Sl.No.	Characters	Vector 1	Vector 2
1.	Grain yield (g)	0.055	0.004
2.	Plant height (cm)	0.250	0.856
3.	Days to 50 per cent flowering	0.049	0.191
4.	Days to maturity	0.035	0.160
5.	Inflorescence length (cm)	0.073	0.146
6.	Stem girth at collar region (cm)	0.003	-0.0001
7.	Number of branches	0	0
8.	Number of rachis	0.095	0.180
9.	Fresh weight of the plant (g)	0.858	-0.336
10.	Fresh weight of the inflorescence (g)	0.419	0.047
11.	Dry weight of the stem (g)	0.063	0.188

selecting desired genotypes from cross combinations involving genotypes from the diverse groups. In this regard the genotypes viz., SDI-66, IC 35380 and **Annapurna** which showed highest diversity should generate large variability and selection could be adopted for high yielding varieties.

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ISPGR DIALOGUE 1993

The Indian Society of Plant Genetic Resources organized a Dialogue on 1-2 December, 1993 at New Delhi on some issues relating to Plant Genetic Resources in India with the aim of developing options for consideration of policy makers. Presentations by panelist and follow up discussions in four technical sessions highlighted PGR Conservation Issues, PGR Ownership and Accessibility, Biodiversity and Biotechnology and also Breeder's Rights and Farmer's Right. A noteworthy feature of this Dialogue was a well designed poster session depicting a wide spectrum of PGR activities in India and providing an excellent opportunity for on-spot discussions and exchange of information.

The publication **PLANT GENETIC RESOURCES IN INDIA — DEVELOPING NATIONAL POLICY OPTIONS** contains a transcript of recorded proceedings of 2 day Dialogue and presents primarily panoramic view of prevalent perceptions and opinions among Indian workers on some key aspects of PGR that have a direct bearing upon policy makers. These viewpoints also suggest some positive options for considerations of Indian policy makers and managers of plant genetic resources.

Poster Session provided national PGR perspective on various crop species and their genepool; highlighted germplasm collecting, evaluation, documentation, conservation, utilization and management; exposed concern on usefulness of wild relatives and plants of future importance; provided information pertaining to germplasm utilization and genetical studies and covered other emerging issues related to Dialogue, biotechnology, conservation etc. The **FULL LENGTH PAPERS OF THE POSTER SESSION** are being published in two special issues of **Indian Journal of Plant Genetic Resources** i.e. Vol. 7 No. 2 and Vol. 8 No. 1 and will be available to all the registered participants and members of Indian Society of Plant Genetic Resources.

ANNOUNCEMENTS

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17-23 November, 1996

NEW DELHI 110 001, INDIA

Sponsored by :

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2. Indian Agricultural Research Institute, New Delhi
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2. Integration and application of knowledge from Crop Science to the following issues as well as adoption of an inter-disciplinary approach involving other areas of agriculture :

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The Congress programme will be organized in the form of plenary sessions, symposia, voluntary poster papers and professional tours. It will be aimed at projecting the activities of crop scientists from all regions of the world. It will provide a forum for interaction with a view to integrate knowledge from crop science and ancillary research areas to solve global and regional problems and issues. In addition, there would be entertainment, meal functions, recreational and agricultural tours so as to acquaint the participants with Indian culture and history.

- CONGRESS INFORMATION

To obtain information about the Congress, please write to :

- Dr Suresh K. Sinha, Secretary General, Second International Crop Science Congress, IARI, Pusa, New Delhi - 110 012, INDIA with the following details:

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