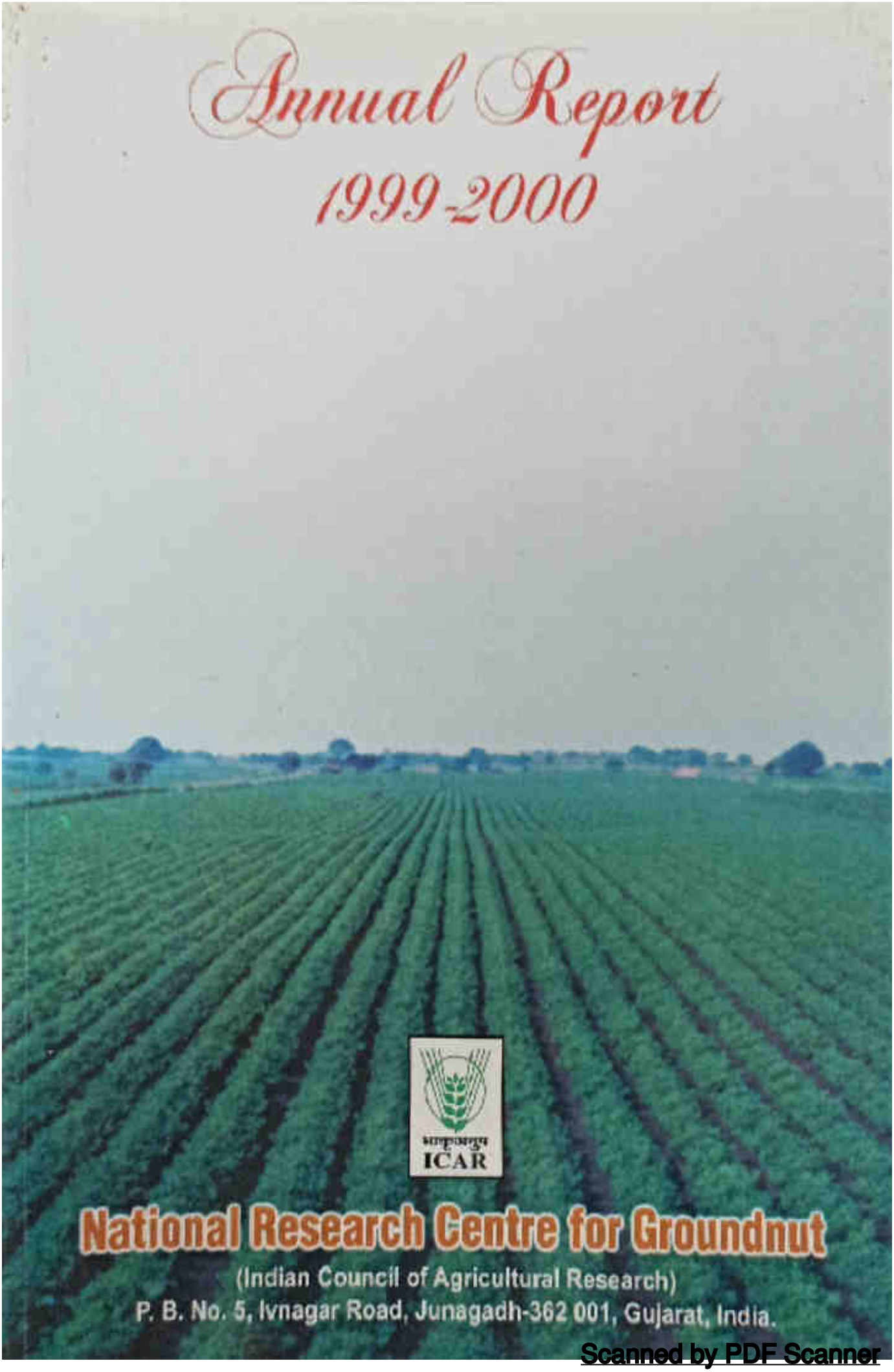
Annual Report
1999-2000



ICAR

National Research Centre for Groundnut

(Indian Council of Agricultural Research)

P. B. No. 5, Ivnagar Road, Junagadh-362 001, Gujarat, India.

ANNUAL REPORT

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PREFACE

During the year 1999-2000, the Centre has gone ahead a great deal with emphasis on its primary mandate, i.e. on basic research. The groundnut gene pool was enhanced substantially by adding further 394 accessions of the cultivated groundnut and 42 accessions of wild species from ICRISAT. Characterization of available germplasm also was given added attention. We have prepared a compendium on elite germplasm and catalogues of 70 released cultivars and 700 germplasm accessions. Extensive screening and artificial hybridization programmes were taken up with a view to tackle the problems of biotic and abiotic stress. The development of protocols for DNA finger printing of the Indian cultivars and the enhanced germplasm went on with a sense of urgency. A considerable progress has also been made in the optimization and application of the genetic transformation protocols for directed approaches to crop improvement.

Stress was given on the development of biofertilisers of various types like growth promoters, phosphate uptake enhancers and bradyrhizobia. Long-term experiments on nutrient dynamics in predominant groundnut based inter cropping and cropping sequences and morpho physiological compatibilities of genotypes in intercrops

Development of an integrated pest management system based on the least use of chemicals has been our priority in the crop protection research.

As a part of national endeavor, collaborative research in North Eastern Hill Regions for promoting and solving the problems of groundnut has been continuing.

Through the Institute Village Linkage programme, we have been quite active in transfer of technology also.

For augmenting the resources, we could be able to tap external funding for six research projects and resolute efforts are in to achieve the set goals.

We shall be grateful to receive suggestions, if, any which would help us to improve the quality and content of the future reports.

A. Bandyopadhyay

(A. Bandyopadhyay)

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ABOUT THE INSTITUTE

The National Research Centre for Groundnut (NRCG) was established in the year 1979 by the Indian Council of Agricultural Research (ICAR).

With the drafting of the perspective plan 'NRCG Vision-2000', the mandate of the Centre was reoriented to provide basic and strategic research support backstopping to the National Agricultural Research Systems on groundnut. Accordingly, the revised mandate is as follows.

- Conduct basic and strategic research to enhance production, productivity and quality of groundnut.
- Act as the national repository of working collection of groundnut germplasm and information on groundnut research.
- Establish relevant institutional linkages, offer consultancy and training, and
- Provide logistic support and coordination mechanism for generation of location specific technology through the All India Coordinated Research Project on Groundnut.

The research activities of the Centre are carried out by nine scientific sections: Genetic Resources, Plant Breeding, Genetics and Cytogenetics, Agronomy, Biochemistry, Plant Pathology, Entomology, Plant Physiology and Microbiology. Eleven research projects have been formulated to achieve the Centre's mandate during IX plan period and appropriaste strategies have been followed for the successful implementation of these projects. In addition, projects funded by external funding agencies are also being implemented at the Centre. the supporting sections of the Centre are: Library, Farm, Establishment and Audit & Accounts.

The NRCG is located 4 km away from Junagadh main town on the Junagadh-Ivnagar road. Junagadh is connected by road and metergauge railway line to Ahmedabad which is 376 km away. The nearby airports are Keshod which is 35 km away and Rajkot which is 110 km away.

The Centre lies on 70.36°E longitude and 21.31°N latitude at an altitude of 60m above mean sea level. The landscale of the area is generally flat. The soils are medium-black and shallow, with depths ranging from 6" to 18".

The climate of this area is semi-arid with a rainfall ranging from 800 to 1000mm. The rainfall is highly erratic and more than 90 per cent of the rain is received during June to September with several intermittent long dry spells. The monsoon rains generally commence by the third week of June but sometimes delayed till the first week of August. The winter showers are meagre and rare. The drought is a rule rather than an exception not only for Junagadh but for the entire Saurashtra region. The occurrence of frost is rare in this region.

AGRO-METEOROLOGICAL DATA OF JUNAGADH FOR THE YEAR 1999-2000

Months	Temp°C		Relative humidity (%)	Rainfall mm/ rainy days	Soil Temp°C		Wind velocity mm/hour	Sunshine hours/ day
	Max.	Min.			5 cm.	10cm.		
April' 99	39.70	22.00	85.60	000.0 (O)	39.72	36.57	8.18	10.28
May '99	35.85	25.17	85.25	001.5 (1)	39.17	37.18	11.97	8.40
June' 99	34.52	26.17	87.25	081.6 (6)	36.22	34.78	11.42	4.80
July'99	30.96	25.60	91.80	230.6 (6)	29.88	29.68	10.26	1.24
Aug' 99	30.72	24.17	93.00	028.1 (5)	30.33	29.76	7.90	2.20
Sept' 99	34.05	23.80	87.75	020.7 (2)	34.23	33.08	6.80	7.47
Oct' 99	34.32	20.38	82.60	033.3 (3)	32.05	30.71	4.92	7.70
Nov' 99	33.55	15.00	65.50	000.0 (0)	30.81	28.92	4.47	8.47
Dec' 99	31.52	10.12	69.75	000.0 (0)	27.93	26.05	4.45	8.15
Jan'00	31.08	13.20	73.00	000.0 (0)	26.85	26.01	3.58	8.48
Feb' 00	31.67	16.17	56.00	000.0 (0)	28.31	27.61	4.52	9.72
Mar' 00	34.75	19.37	54.75	000.0 (0)	32.61	31.26	5.47	9.27

सारांश

शोध, प्रसार तथा मानव संसाधन विकास के क्षेत्र में किये गये कार्यों के परिणामों का सारांश निम्नवत दिया जा रहा है :-

क: अनुसंधान

फसल सुधार :

मूल्यांकन तथा अभिलक्षण निश्चयन के विभिन्न परीक्षणों में सैनिश अभिगमनों में से उपज के लिए NRCGs 10273, 10334, 10443 तथा 11429, कनफेक्शनरी गुणों के लिए NRCGs 11900, 11903 एवं 11952 तथा अगेती व पछेती पर्णधब्बा एवं रस्ट रोगों के प्रति प्रतिरोधकता/सहिष्णुता के लिए NRCGs 10950, 11001, 11597, 11003, 11004, 11005, 11014, 11060, 11062, 11069, 11072, 11073, 11580, 11525, 11596, 11590, 11609, तथा 11616 की पहचान होनहार के रूप में की गयी ।

बीजों में प्रोटीन के लिए सत्तर विमोचित किस्मो का SDS PAGE द्वारा विश्लेषण किया गया और उच्च आणविक भारीय प्रोटीन (126 एवं 113 kd) तथा कम आणविक भारीय प्रोटीन (30 एवं 7 kd के बीच) के लिए polymorphism का अवलोकन किया गया ।

भ्रूणहीन किये गये बीजपत्रकों (de-embryonated cotyledons) से उत्पन्न बहुप्ररोहों के पात्रीय (in vitro) संरक्षण अध्ययनों में पाया गया कि 2% से न्यूनतापूर्तित बहुगुणक संवर्धक ने प्ररोहो के ओज को बिना कम किये उप-संवर्धन अवधि को बढ़ाया ।

एरैकिस की 13 प्रजातियों में तने का रोमपन व रंग, पत्ती का रोमपन व रंग, पुष्पो का रंग, पत्तो के डंठल का रोमपन, पुष्पांक स्फीति की लंबाई और मानक दलपत्र की लंबाई तथा चौड़ाई के लिए numerial-taxonomic विश्लेषण द्वारा 21 अभिगमनों का वर्गीकरण व लक्षण-निश्चयन किया गया । गुणवत्ता सम्बन्धी अधिकतर लक्षणों में काफी अन्तर पाया गया ।

वर्षा तथा वर्षा के बाद के मौसम में भुवनेश्वर में किए गये मूल्यांकन परीक्षण में पाया गया कि वर्जीनिया बन्च के 126 अभिगमनों में से 11 अभिगमनों यथा ICGs 500, 4520, 4805, 5656, 11998, 1643, 2630, 2689, 6434 एवं 6740 को उपज के लिए होनहार पाया गया । धान के बाद खाली खेत की अवशिष्ट नमी की दशा के अन्तर्गत मूल्यांकित वर्जीनिया बन्च के 126 अभिगमनों में से 5 अभिगमनों यथा ICGs 4515, 6098, 6739, 6794 व 11998 की प्रगति स्थानीय चेक की तुलना में उत्तम पायी गयी ।

कार्य संबंधी सबन्ध्यता उत्पन्न करने हेतु किये गये एक प्रयोग में इन्डोल एसिटिक एसिड, इन्डोल ब्यूटारिक एसिड तथा जिब्बरेलिक एसिड का पर्णीय छिड़काव करने पर क्रमशः 28%, 50% तथा 18% पराग बन्ध्यता पायी गयी ।

रासायनिक उत्प्रेरकों से उपचारित गिरनार 1 के व्युत्पन्न से प्राप्त M2 पीढ़ी में आनुवांशिक परिवर्तनता की पहचान संकुत (अप्रभावी) प्रकृति की पायी गयी ।

कृत्रिम संकरण के दरम्यान स्वनिषेचित फलियों को कम करने के लिए पुष्पों को हटाने की आदर्श अवधि की पहचान कर ली गयी है, जो कि खरीफ मौसम में प्रातः 7 बजे से पूर्व पायी गयी ।

सर्वोत्तम जननद्रव्यों का एक संग्रह प्रकाशित किया गया और 70 विमोचित प्रजातियों एवं 700 जननद्रव्य अभिगमनों की सूचीपत्र तैयार की गई ।

खरीफ 1999 में विभिन्न उद्देश्यों के लिए कुल 66 प्रसंकर बनाये गये । कुल 620 कल्चरों का गुणन किया गया । अगले मूल्यांकन हेतु 82 अग्रिम प्रजनक कल्चरों का चयन किया गया और संकरण के लिए 28 जोड़ियों का चयन पैतृकों के रूप में किया गया । F1 में 99 प्रसंकरों, F2 में 80 प्रसंकरों, F3 में 95 प्रसंकरों, F4 में 21 प्रसंकरों, F5 में 41 प्रसंकरों तथा F6 पीढ़ी में 21 प्रसंकरों को आगे बढ़ाया गया और कुल 55 चयन किए गए ।

PBS nos. 13013, 14026, 18004, 21063, 22017, 22026. 24009, 30016 एवं 30021, कोड 7, कोड 11, कोड 26 और CS19 को कॉलर रॉट के लिए मध्यम प्रतिरोधक तथा PBS 11048, 11052, 22011 एवं 30138 ने पछेती पर्णधब्बा एवं रस्ट दोनों के लिए प्रतिरोधकता दर्शायी, PBS 23019 रस्ट के लिए प्रतिरोधक एवं पछेती पर्णधब्बा तथा *Helicoverpa* एवं *Spodoptera* के प्रति मध्यम प्रतिरोधक पाया गया ।

कल्चर PBS 23003, 24005, 24006, 24030 तथा 24040 ने थ्रिप्स के विरुद्ध प्रतिरोधकता दर्शायी और PBS 23003 को थ्रिप्स व एफिड दोनों के प्रति प्रतिरोधक पाया गया । गिरनार 1 से प्राप्त दो व्युत्पन्नों PBS 30001 तथा TSP 60 ने भंडारण कीट ब्रुचिड बीटल के प्रकोप के प्रति प्रतिरोधकता दर्शायी । गिरनार 1 का रासायनिक उत्प्रेरण से प्राप्त व्युत्पन्न PBS 3000 जो JL24 से 13% अधिक पैदा कर देता है, ने भी कि भंडारण कीट ब्रुचिड बीटल के प्रति प्रतिरोधक पाया गया ।

जननद्रव्य PBS 21063, 23003, 24004, 24040 तथा FSD 66 को लौह की कमी से जनित क्लोरोसिस के प्रति सहिष्णु पाया गया ।

बीज भंडारण की क्षमता को बढ़ाने के लिये GAUG 1 (सहिष्णु) तथा GG 2 (ग्राह्य) को क्रॉस करने के पश्चात जननद्रव्यों FSD 7, FSD 36, FSD 46 तथा FSD 68 के बीजों में भंडारण की क्षमता में भारी सुधार पाया गया क्योंकि इनके ग्रीष्मकालीन उत्पाद को 15 महीनों तक व्यापक दशाओं में भंडारण के बाद भी 25 प्रतिशत अंकुरण पाया गया ।

सामान्य परिस्थिति एवं मृदा लवण की कमी की स्थिति में constituent cultivars की तुलना में तीन कल्चरों के varietal blend ने अच्छा प्रदर्शन नहीं किया ।

पत्ती का उत्परिवर्ती गुण नीबूत पीत एक एकलिंगी अप्रभावी जीन द्वारा नियंत्रित होता है और Ly को हरे तथा ly को पीत जीन-चिन्ह के रूप में प्रस्तावित किया गया । मूँगफली में पुष्प अक्ष पर पुष्पीकरण का गुण द्विगुणित जीनों के दो

जोड़ों जो कि duplicate epistatic manner में परस्पर प्रतिक्रिया करते हैं, के द्वारा नियंत्रित होता है । मूँगफली में फली के आकार का गुण duplicate loci के दो जोड़ो जो कि *loci* के बीच परस्पर प्रभावी प्रतिक्रिया करते हैं, के द्वारा नियंत्रित होता है । द्विगुणित जीनों के दो जोड़ों P1/p1; P2/p2 तथा Q1/q1; Q2/q2 को फली आकार के लिए प्रस्तावित किया गया है ।

मूँगफली में चूना-जनित लौह की कमी से उत्पन्न हरिम-हीनता के प्रति सहिष्णु जननद्रव्यों की स्क्रीनिंग हेतु पर्णहरित मीटर (SPAD-502 Minalta, Japan) का उपयोग करके एक आसान तरीका स्थापित किया गया । फिन्गर प्रिंटिंग और आगे लक्षण निश्चयन के लिए 70 विमोचित कल्टीवारों में से प्रत्येक के दो नमूनों से genomic DNA का पृथकीकरण, शुद्धीकरण, अवगणना व भंडारण किया गया ।

आकारकीय संकेतक जीनों को जो कि चिन्हन-सपन्न चयन करने के लिए उपयुक्त हों, की पहचान के उद्देश्य से 10 चिन्हन करने वाले जननद्रव्यों के साथ 24 क्रॉसों का प्रयास किया गया और संभावित संकर फलिवों को प्राप्त किया गया ।

अपरिपक्व पत्तियों के लिए कायिक भ्रूणों के प्रवेशन हेतु एक नये कार्य प्रारुप (protocol) को विकसित किया गया । इस protocol से लाभ है कि मौसमी फसल से स्वतंत्र genetic manipulation अध्ययन के लिए कायिक भ्रूणों को उत्पन्न किया जा सकता है ।

आनुवांशिक परिवर्तन के लिए GG 2 प्रजाति के कायिक भ्रूणों को *Agrobacterium* co-culture में उपयोग किया गया । Hygromycin के द्वारा चार पौधों को चयन चक्र से गुजारा गया । परिवर्तन के लिए *Agrobacterium* संवर्धित तरीके का उपयोग करके भ्रूणरहित बीजपत्रकों, परिपक्व भ्रूणों तथा भ्रूणीय अक्ष और अपरिपक्व पत्तियों का उपयोग किया गया । Co-cultivation के बाद ex-plant को बहुप्ररोहों (जो hygromycin युक्त संवर्धक में चयनित किया जा सकते हों) को उत्पन्न करने हेतु BAP युक्त MS संवर्धक में स्थानान्तरित किया गया ।

पर्ण-सुरंगियों के नाश के लिए *E. coli* जीवाणु कल्चर, जिसमें CrylAc प्रोटीन over express हुए, का शुद्धीकरण एवं परीक्षण किया गया और प्यूपा की 100% mortality उत्पन्न करने के लिए 0.5 माइक्रोग्राम/माइक्रोलीटर सांद्रता उपयुक्त पायी गयी ।

फसल उत्पादन :

दो अन्तरशस्यीय प्रणालियों यथा मूँगफली+अरहर और मूँगफली+बाजरा के लिए मूँगफली की 25 प्रजातियों की स्क्रीनिंग ने संकेत दिया कि मूँगफली के जीवांगों में बाजरा के साथ फली उत्पादन में कमी (51% तक) पायी गयी । सामान्यतः जब मूँगफली की प्रजातियों को अन्तरशस्य में उगाया गया तो स्पैनिश की अपेक्षा वर्जीनिया प्रजातियों की उपज में अधिक कमी पायी गयी । अन्तरशस्य के कारण वर्जीनिया में GG 2, M 335 तथा M 13 और स्पैनिश में J 11, GG 4 तथा GG 2 ने फली उत्पादन में कम कमी दर्शायी । मूँगफली+अरहर प्रणाली ने दोनों फसलों में संस्तुत उर्वरकों की केवल 50% मात्रा तक प्रत्युतर दिया जबकि मूँगफली+बाजरा प्रणाली में बाजरा ने उर्वरकों की मात्रा का सीधा प्रत्युतर दिया लेकिन जैसे-जैसे इस प्रणाली में उर्वरकों की मात्रा बढ़ायी गयी, मूंगफली की उपज में

लगातार कमी पायी गयी । मूँगफली+बाजरा अन्तरशस्यीय प्रणाली में मृदा में प्राप्त नत्रजन, खासतौर पर NH_4^+ प्रकार में विभिन्नता पायी गयी ।

फसल सघनता के साथ मृदा के राइजोस्फीयर (0-15 cm) के pH में वृद्धि पायी गयी । मूँगफली की एकल फसल की अपेक्षा शस्य सघनता 200% (बाजरा के साथ अन्तरशस्य तथा गेहूँ के साथ अविराम शस्य) तथा 300% (गेहूँ और मूँग के साथ अविराम फसलचक्र) का pH अधिक पाया गया । परन्तु सभी फसल सघनताओं (चाहे कोई भी फसल हो), FYM ने मृदा pH को कम किया ।

बीज मल्च की तुलना में कार्बनिक अवशिष्टों (गेहूँ व धान का भूसा) की 5 टन/है. की दर से मल्चिंग ने ग्रीष्मकालीन मूँगफली की फली उत्पादन में 21% की वृद्धि की । पारदर्शी और काली पॉलीथीन (10 तथा 50 माइक्रोन) के कारण उत्पादन में मध्यम (13% वृद्धि) पायी गयी । हालाँकि जब गेहूँ के भूसे के मल्च को काली पॉलीथीन (50 माइक्रोन) के साथ संयोजित किया गया तो फली उत्पादन में अधिकतम वृद्धि (26%) अभिलेखित की गयी ।

खरीफ में मूँगफली आधारित शस्य प्रणाली में एक नवीन (उगने से पूर्व) तृणनाशी "Napromamide" (एमाइड वर्ग) का मूल्यांकन किया गया । खरीफ मूँगफली में नये तृणनाशी Napromamide द्वारा खरपतवारों (एक व द्विदलीय) का नियंत्रण संस्तुत तृणनाशी (Pendamethalin @ 1.5 Kg ai/ha) की तुलना में समान ही पाया गया । हालाँकि Napromamide के विचारणीय अवशिष्ट प्रभाव ने आगे वाली गेहूँ की फसल के अंकुरण, वृद्धि तथा उपज को कम किया । चने की फसल पर किसी भी प्रकार का अवशेषित प्रभाव परिलक्षित नहीं पाया गया ।

विगत दो ग्रीष्म मौसमों में पाया गया कि प्रचालित, Windrow तथा DOR विधियों की अपेक्षा NRCG विधि (tripod-thatching arrangement) के अनुसरण से सुखायी गयी कलियों से प्राप्त बीजों में उच्च अंकुरण व पौध ओज बरकरार रखने की क्षमता पायी गयी । NRCG विधि ने बेहतर अंकुरण क्षमता दर्शायी क्योंकि इस पद्धति में यह लाभ है कि यह फलियों को सीधे सूर्य के प्रकाश व वर्षा से बचाये रखती है ।

स्पैनिश प्रकार की मूँगफली के अन्दर सुसुप्तावस्था (dormancy index) में 2% (प्रजाति Chico) से 88% (प्रजाति ICGS 44) तक की विभिन्नता पायी गयी । कम DI (>10%) वाली प्रजातियाँ जैसे प्रजाति Chico (20%), TAG 24 (15%) तथा GG 2 (14%) में फलियों का खेतों में ही प्रस्फुटन होने की वजह से अधिक नुकसान पाया गया । प्रजाति SB XI ने खेतों में कोई प्रस्फुटन नहीं दर्शाया इसलिए फलियों का नुकसान नहीं हुआ । प्रयोगशाला में ताजा बीजांकुरण प्रतिशत तथा खेत में दानों के प्रस्फुटन के बीच सीधा संबंध पाया गया ।

छोटे बीज वाली मूँगफली की प्रजातियों की अपेक्षा बड़े बीज वाली प्रजातियों की कैल्शियम की आवश्यकता अधिक पाई गई । कैल्शियम के स्तर को 200 ppm तक बढ़ाने पर बीजों में कैल्शियम की सान्द्रता व फलियों की उपज बढ़ी । बड़े बीज वाली मूँगफली में पोटाश के 100 ppm तथा कैल्शियम के 200 ppm के संयोजन को उच्च फली उत्पादन हेतु उत्तम पाया गया । इसलिए बड़े बीज वाली मूँगफली में उचित पोषक तत्वों के लिए कैल्शियम और पोटाश दोनों की संतुलित मात्रा का अनुप्रयोग आवश्यक पाया गया ।

ICGV 76, ICGV 86590, ICGS 11, ICGS 44, ICG 1045, Girnar 1, और TKG 19 A ने उत्तरपूर्वी पहाड़ीक्षेत्रों में एल्यूमिनियम विषाक्तता तथा फॉस्फोरस व कैल्शियम की कमी के कारण होने वाले लक्षणों के प्रति सहिष्णता दिखायी ।

उत्तरपूर्वी पहाड़ी क्षेत्रों की अम्लीय भूमि को NPK उर्वरक, गोबर की खाद, *Bradyrhizobium* तथा चूने की मदद से भूमि की अम्लीयता को कम करने की कोशिश की गयी तथा चूना + फोस्फरस + PSM के द्वारा भूमि को सुधारने में बहुत मदद मिली व इससे त्रिपुरा में मूँगफली का उत्पादन भी दुगना पाया गया ।

ग्रन्थियों के निर्माण में *Bradyrhizobium* के दो विभेदों AS6 तथा As9 को बहुत ही दक्ष पाया गया । पौधों की वृद्धि को उत्साहित करने वाले तीन कल्चरों PGPR1, PGPR2 तथा PGPR4 को *Aspergillus flavus* की वृद्धि को रोकते हुए पाया गया । इन कल्चरों के inoculation से गमलों के अलावा खेतों में भी फली उत्पादन में सार्थक वृद्धि हुई ।

विषैले *rhizobacteria* जो कि घातक थे, ने मूँगफली की प्रजाति JL24 के फली उत्पादन को 42% तक कम किया और ग्रन्थियों के निर्माण को भी रोका अथवा बाधित किया ।

दो ब्रेडीराइजोबियम आइसोलेटों (PSM1 तथा PSM5) ने खेत में फली उत्पादन, पौधों के जैव भार, ग्रन्थियों के शुष्कभार तथा फॉस्फोरस ग्राह्यता (भूमि से खींचना) में सार्थक वृद्धि की । तथा एक प्राकृतिक परजीवी (*Anisopteromalus calandrae*) के दोहरे अनुप्रयोग से मूँगफली के भयंकर भंडारण कीट ब्रुचिड की संख्या का प्रभावी नियंत्रण हुआ ।

मूँगफली की फसल में पोषक तत्वों की आवश्यकता की पूर्ति तथा नाशीजीव मुक्त उत्पादन के लिए विभिन्न पर्यावरण हितैषी व कार्बनिक कृषि तरीकों (FYM, गाय/ पालतू पशुओं के गोबर का घोल, मूँगफली-कपास के बेकार के अवशिष्टों, तिलहनों की खलियां, स्थानीय पौधों/ खरपतवारीय पदार्थों तथा जैव उर्वरकों) का मूल्यांकन किया गया । FYM, तिलहनों की खलियां तथा पशुओं के गोबर के घोल को सर्वाधिक आशाजनक पाया गया ।

दक्ष ब्रेडीराइजोबियम आइसोलेट 39 के spontaneous refampicium resistant mutants की पहचान की गयी और गमलों मे टेस्ट किया गया । NRCG 4 तथा NRCG 7 आइसोलेटों ने ग्रन्थियों की उपलब्धता को 69% तक दिखाया ।

विमोचित प्रजातियों में प्रजाति BAU 13 को उच्च प्रोटीन-उच्च सुक्रोज-उच्च स्थिरता (कम अधिक के लिए) तथा प्रजाति TMV 7 को उच्च प्रोटीन-कम सुक्रोज-कम स्थिरता के रूप में पहचाना गया ।

स्थिर पीढ़ियों से इच्छित confectionery गुणों वाले 19 कल्चरों को आगे संकरण में उपयोग करने हेतु चयनित किया गया ।

GG 2 में बीजों का भार 100 मि.ग्रा. से 300 मि.ग्रा. बढ़ने के साथ-साथ O/L अनुपात में वृद्धि हुई और [illegible] प्रजाति गिरनार 1 में कोई निश्चित अनुपात नहीं पाया ।

बीजो मे प्रोटीन के, PAGE ने छोटे आकार के बीजों मे कुछ प्रोटीन-बैंडों की कमी दर्शायी जो कि बड़े बीजो मे स्पष्ट पाई गई ।

यूरिया (@ 200 ग्रा./ कु.) तथा *Bacillus sp.* के साथ 90 दिन तक सड़े हुए मूँगफली के छिलकों ने मूँगफली की उपज तथा संबंधित गुणो में सार्थक वृद्धि की । बुवाई से पूर्व स्व स्थान (*in situ*) पर सड़ने के लिए जब मूँगफली के छिलकों (@ 15 टन/ है.) के साथ *Bacillus* का अनुप्रयोग किया गया तब फली उत्पादन, जैव भार तथा नत्रजन में वृद्धि हुई ।

फसल सुरक्षा :

ग्रीष्म ऋतु में बनावटी नाशीजीव (मूल्य रु. 2000) के छिड़काव से प्राप्त उत्पादन (2727 कि.ग्रा./है.) के समान ही अन्तिम आर्थिक स्तर (ETL) पर आधारित 2% कच्चे नीम के छिड़काव से उत्पादन (2627 कि.ग्रा./ है.) प्राप्त हुआ ।

खरीफ मौसम में *Spodoptera, Helicoverpa* के लिए टीपोल में 2% CNO (ETL पर आधारित) + फेरोमोन ट्रैप से युक्त IPM module का उपयोग तथा पूर्ण सुरंगी + ट्रैप फसलें (सोयाबीन तथा अरहर अन्तराशस्य के रूप में) ने कुल आर्थिक लाभ का बेहतर तथा सार्थक परिणाम दिया ।

मूँगफली के प्रमुख भंडारण कीट *Caryedon serratus* में सर्वप्रथम grub instars की पहचान की गयी ।

एफिड (*Aphis craccivora*) की कीट संख्या नवम्बर से फरवरी तक अधिक पायी गयी । पर्णसुरंगियां पूरे वर्ष सक्रिय रहीं लेकिन फरवरी में अधिकतम तथा इसके बाद सितम्बर से दिसम्बर तक निरंतर बढ़ती रहीं ।

मूँगफली में पर्णसुरंगियों के विरुद्ध विभिन्न *instars* के लिए *Bacillus thurungiensis* (*Bt*) प्रोटीन का परीक्षण किया गया । CryIAc प्रोटीन के अनुप्रयोग के एक सप्ताह बाद परिणाम आया कि प्रथम और द्वितीय में मृत्युदर लगभग 48% पायी गयी जो घटकर तृतीय *instar* में 16% तथा चतुर्थ *instar* में 11% रही । इस स्पीशीज के पाँचवे instar मे कोइ मृत्युदर नहीं पायी गई ।

एस्पर्जिलस नाईजर के द्वारा बीजों में उपनिवेशन के प्रति प्रतिरोधकता के लिए चार जीन प्ररुपों जैसे ICGV 87280, ICGV 86594, PBS 5 तथा J 11 की पहचान की गई । TKG 19A तथा J 11 को एस्पर्जिलस फ्लैवस द्वारा बीजीय उपनिवेशन के प्रति प्रतिरोधक पाया गया ।

Trichoderma harzianum को 4 ग्रा./ कि.ग्रा. बीज की दर से बीजोपचार करने से तना सड़न पर 40% नियंत्रण पाया गया । सरसों की खली के 1000 कि.ग्रा./है. की दर से अनुप्रयोग करने पर तना सड़न पर 57% तक नियंत्रण पाया गया । रस्ट की सघनता को 29% तक कम करने में मूँगफली + ज्वार की अन्तरशस्य खेती उपयोगी पाई गयी । तना सड़न को 63% तक नियंत्रण करने में दो फसल चक्र मूँगफली - गेहूं-मूँगफली तथा upland धान - मूँगफली - upland धान को उपयोगी पाया गया ।

यह तथ्य सामने आया कि अन्तरशस्यों (कपास, अरंडी, ज्वार, बाजरा व अरहर) से एस्पर्जिलस फ्लैवस द्वारा संक्रमण तथा उपनिवेशन मे कोई सार्थक बदलाव नहीं आया ।

प्रमुख कवकीय रोगों (ELS, LLS, rust) के नियंत्रण में फफूंदीनाशक मिश्रण (कार्बेन्डाजिम 0.05% + मैंकोजेब 0.2%) तथा सरसों की खली के जलीय अर्क (5%) का पर्णीय अनुप्रयोग प्रभावी पाया गया ।

ख : प्रसार शिक्षा

कृषकों की परंपरागत पद्धति द्वारा प्राप्त कुल राशि रु. 17360/ है. की अपेक्षा NATP के अन्तर्गत TAR-IVLP परियोजना के तहत मूँगफली तथा अरहर अन्तर्शस्यीय प्रणाली में संयुक्त पोषक तत्वों के प्रबंधन (INM) के द्वारा कुल आर्थिक लाभ अधिक लगभग रू. 3600/ है. मिला । सत्यापन परीक्षणों में संयुक्त नाशीजीव प्रबंधन (IPM), जिसमें बीजोपचार, नीम के तेल का छिड़काव, जैव नियंत्रक, अरंडी की खली से मृदा सुधार, अवरोधी फसलें तथा फेरोमोन ट्रैप्स आदि कारक सम्मिलित हैं, के उपयोग ने मूँगफली में किसानों की पद्धति की अपेक्षा 21% अधिक फलियों का उत्पादन दिया । प्रमुख मृदाजनित रोगों तथा कॉलर रॉट के प्रक्षेत्र परीक्षण प्रबंधन में अरंडी की खली 1टन / है. की दर से अनुप्रयोग ने कॉलर रॉट को 62% तक तथा तना सड़न को भी समान रुप से नियंत्रित किया गया । किसानों को प्रशिक्षण भी दिया गया ।

ग : मानव संसाधन विकास

ग्यारह लोगों को सेमिनार तथा शैक्षणिक कार्यक्रमों मे भाग लेने के लिए भेजा गया ।

घ : विकास एवं प्रशासनिक कार्य

दस तकनीकी कर्मचारियों को पदोन्नति तथा पाँच को अग्रिम वेतन वृद्धि का लाभ दिया गया।

केन्द्र पर कार्यरत चार वैज्ञानिकों को भारतीय कृषि वैज्ञानिक चयन आयोग द्वारा पदोन्नति करके वरिष्ठ वैज्ञानिक के पद पर नियुक्त किया गया ।

बाहर निवासीय मकान जिनमें 6 टाइप III तथा 6 टाइप IV श्रेणी के बनाये गये तथा उनका आवंटन किया गया ।

बिजली के सभी पुराने लोहे के जंग लगे हुए खंभों को सीमेंट के खंभों से बदला गया ।

कर्मचारियों के भविष्यनिधि में रखे गये धन को नियंत्रित करने के लिए Excel तथा Access में एक Software कार्यक्रम बनाया गया जो कि सुचारु रुप से कार्य कर रहा है ।

- A new protocol for induction of somatic embryos for immature leaves was standardised. This protocol has advantage of producing somatic embryos for genetic manipulation studies, independent of the crop season
- Somatic embryos from the cultivar GG2 were used in the *Agrobacterium* co-culture for genetic transformation. Four plants passed through the cycles of selection by hygromycin. De embryonated cotyledons, mature embryos and embryonic axes and immature leaves were also used for transformation using the *Agrobacterium* mediated method. The explants after co cultivation were transferred to MS medium containing BAP to induce multiple shoots, which could be selected in hygromycin containing medium.

Crop Production

- Screening of 25 groundnut cultivars for two intercropping systems viz.; groundnut+ pigeonpea and groundnut +pearl millet, indicated that yield reduction in groundnut genotypes was more with pigeonpea (up to 78 %) than that of with pearl millet (up to 51%). In general, yield reduction was more in virginia than spanish cultivars of groundnut when intercopped. The cultivares GG 20, M 335 and M 13 among virginia and J 11, GG 4 and GG 2 among spanish types showed least reduction in pod yield due to intercropping.
- Groundnut+ pigeonpea system responded only up to 50% of the recommended doses of fertilizers to both the crops, whereas in groundnut + pearl millet system, pearl millet responded linearly to the fertilizer doses, but groundnut yield got reduced consistently as fertilizer dose increased in the system. Variation in available soil nitrogen especially the NH4+ type was evident in groundnut + pearl millet intercropping system.
- Soil pH of rhizosphere (0-15cm) increased with the cropping intensity. When the cropping intensity were 200% (intercropping with peral millet and sequential cropping with pigeonpea) and 300% (sequential cropping with groundnut-wheat & groundnut-wheat-greengram) soil pH was higher than mono cropping of groundnut. But FYM, irrespective of cropping intensity, lowered soil pH.
- Mulching with organic residues (wheat straw and paddy straw) @5t/ha increased pod yield of summer groundnut by 21% as compared to no mulching .Moderate increase in pod yield (13%) was observed due to transparent and black polythene (10 & 50 micron guage). However, the maximum increase in pod yield (26%) was recorded when wheat straw mulch was combined with black polythene (50 micron).
- A new pre-emergence herbicide "Napropamide" (Amide group) was evaluated in kharif groundnut based cropping system. In kharif groundnut, weed control (mono and dicot weeds) by "Napromide a new herbicide was observed to be similar to that by the recommended herbicide (Pendimethalin @ 1.5 kg ai/ha). However, a considerable residual effect of Napropamide reduced germination, growth and yield of the succeeding wheat crop. No residual effect was observed on gram.

- Among released cultivars, BAU 13 was identified as a high protein-high-sucrose-high stability (for shelf life) cultivar and TMV 7 as high protein-low sucrose-low stability cultivar.
- Nineteen cultures with desirable confectionery attributes were selected for further use in hybridisation from the stablized generations.
- The O/L ratio value increased with increase in seed mass from 100 to 300 mg and then remained constant in GG 2, while in the cv. Girnar 1, there was no definite pattern.
- PAGE of seed proteins showed that small sized seeds lacked a few protein bands which were conspicuous in large seeds in the same cultivar.
- Groundnut shell composted with urea @ 200g/q of shell and a *Bacillus* sp. for 90 days, significantly improved yield & related traits of groundnut. Pod yield, biomass and N content could be improved when groundnut shell inoculated with *Bacillus* for its *in situ* decomposition was applied @ 15t/ha before sowing.

Crop Protection

- Spray of 2% crude neem oil based on Economic Threshold Levels (ETL) gave similar yield (2627 kg/ha) as spraying synthetic pesticides (worth Rs 2000) (2727 kg/ha) in the summer season.
- During the kharif season, use of the IPM module consisting of 2% CNO in Teepol (based on ETL)+ Pheromone traps for *Spodoptera*, *Helicoverpa* and leaf miner + trap crops (soyabean as intercrop, castor as border crop & pigeon pea as intercrop) resulted in a significantly higher gross monetary return.
- For the first time, the grub instars were identified in *Caryedon serratus*, the most important storage pest of groundnut.
- The population of aphids (*Aphis craccivora*) was maximum from November to February. Leaf miner was active throughout the year, but peaked (though a low peak) in February then steadily increased from September to December.
- Cry IAc protein was over expressed in *E.coli* bacterial cultures purified and tested for mortality in leafminer and a concentration of 0.5 mg/ml was found to be inducing 100% mortality of the pupae.
- *Bacillus thuringiensis* (Bt) proteins were tested against the groundnut leaf miner for different instars. After one week of the application of the Cry IAB proteins resulted in about 48% mortality.

B. Extension

- In the TAR-IVLP project under NATP through integrated nutrient management (INM) a high gross monetary return of Rs.21,384/ha was obtained as compared to 17,360/ha obtained from farmers' practice.

- Seeds obtained from the pods dried following NRCG-method on tripod-thatching arrangement during the last two summer seasons were able to maintain higher seed germinability and seedling vigour than the windrow, conventional, and DOR drying methods. Superiority in maintaining better seed germinability by the NRCG method was mainly because it has the advantages in protecting the pods from direct sunlight, and rain.
- Value of dormancy index varied within the Spanish types of groundnut from 2% in cultivar Chico and 88% in cultivar ICGS 44. Cultivars with lower DI (>10%) for example Chico (20%), TAG 24 (15%) and GG 2 (14%) had more pod losses for the cultivar. SB XI did not showed any in situ sprouting, hence no pod losses. A direct relation (r=0.86) was found between fresh seed germination percentage in the laboratory and plants having sprouted seeds in the field at harvest.
- Large seeded groundnut cultivars had higher requirement of Ca than the small seeded ones. Increasing the Ca level to 200 ppm increased the concentration of Ca in seed and pod yield. A combination of 100 ppm K and 200 ppm Ca was the found best for high pod yield in large seeded groundnut. Thus it is essential to apply balanced doses of both K and Ca for the proper nutrition of bold-seeded groundnut.
- In stragtegic experiments conducted in the North-East Hills region in collaboration with the ICAR Research Complex for the NEH region it was found that application of NPK fertilizerds, lime and FYM reduced the direct and indirect effects of Al-toxicity and increased pod yield by (28% to 62%). In Tripura addition of lime; phosphorus, and PSM doubed the productivity.
- Various organic nutrition sources like, FYM, slurry of cow/domestic animals, briquette from peanut-cotton waste, oilseeds cakes, mulching with local plant/weed material and bio-fertilizers were evaluated to meet the nutrient requirement of the. Application of FYM, oilseed cakes and cow dung slurry were the most promising ones.
- Two *Bradyrhizobium* isolates AS6 and AS9 were found to be very efficient in nodulation. Three plant growth promoting rhizobium cultures, PGPR1, PGPR2 and PGPR4 were found to be inhibitory to *Aspergillus flavus*. Inoculation with these cultures significantly enhanced the pod yields in pots and also in field.
- Deleterious rhizobacteria, which were also cyanogenic, reduced pod yield of groundnut, cultivar JL24, upto 42% and also inhibited nodulation.
- Two phosphate solubilizing acterial isolates, PSM1 and PSM5, significantly enhanced pod yield, plant biomass, nodule dry weight and P uptake in the field.
- Dual application of Bt and a natural parasitoid, *Anisopteromalus calandrae* effectively controlled the population of bruchid, a serious groundnut storage pest.
- Spontaneous rifampicin resistant mutants of 39 efficient *Bradyrhizobium* isolates were identified and tested for nodule occupancy. The isolates, NRCG 4 and NRCG 7 showed upto 69% nodule occupancy.

EXECUTIVE SUMMARY

A summary of the significant achievements in research, extension and other fields have been presented below:

A. Research

Crop Improvement

- In different characterization and evaluation trials, the Spanish accessions NRCGs 10273, 10334, 10443, and 11429 were identified as promising for yield; NRCGs 11900, 11903 and 11952 for confectionary traits and NRCGs 10950, 11001,11597, 11003,11004, 11005, 11014, 11060, 11062, 11069, 11072, 11073, 11580, 11585,11596, 11590, 11609, and 11616 as resistant/tolerant of early and late leaf spot and rust diseases.
- Seventy released cultivars were analysed for seed protein by SDS-PAGE and polymorphism was observed for high molecular weight proteins (126 and 113 kd) and low molecular weight proteins (between 30 and 7 kd).
- In *in vitro* conservation studies with multiple shoots induced from de-embryonated cotyledons, the multiplication medium supplemented with 2% mannitol increased the duration of sub culturing without losing vigour of the shoots.
- Twenty-one accessions of thirteen *Arachis* species were characterized and grouped by numerical taxonomic analysis for stem hairiness, stem pigmentation, leaf hairiness, leaf colour, flower colour, petiole hairiness, length of hypanthium and length and width of standard petals. Wide variance was found for most of the qualitative characters.
- Out of one hundred and twenty six virginia bunch accessions evaluated during rainy and post-rainy seasons at Bhubaneswar, eleven accessions, viz. ICG's 500, 4520, 4805, 5656, 11998, 1643, 2630, 2689, 6434 and 6740 appeared promising for yield. Evaluation of 126 virginia bunch accessions in rice fallows indicated superior performance of five accessions, viz. ICGs 4515, 6098, 6739, 6794 and 11998 compared to local check under the rice fellow situation.
- Foliar spray of Indole acetic acid, indole butyric acid and gibberellic acid could induce 28%, 50% and 18% pollen sterility.
- The inheritance of male sterility identified in the M2 generation of chemical mutagen treated Girnar 1 was recessive in nature.
- To minimize selfed pods during artificial hybridization, the ideal period for removing the buds was identified to be before 7 am during the kharif season.
- A compendium on elite germplasm has been published and catalogues of 70 released cultivars and 700 germplasm accessions have been prepared.
- A total of 66 crosses were made during kharif 1999 for different purposes. A total of 620 cultures were multiplied. Eighty-two advanced breeding cultures were selected

for further evaluation and 28 genotypes were selected as parents for fresh hybridization. Ninety-nine crosses in F1, 80 crosses in F2, 95 crosses in F3, 21 crosses in F4, 41 crosses in F5, 21 crosses in F6 generations were advanced and a total of 55 selections were made.

- The breeding lines PBS Nos 13013, 14026, 18004, 21063, 22017, 22026, 24009, 30016, and 30021, Code 7, Code 11, Code 26 and CS 19 had moderate resistance to collar rot; PBS 11048, 11057, 22011, and 30138 showed resistance to both late leaf spot and rust; PBS 23019 was resistant to rust and moderately resistant to late leaf spot and *Helicoverpa* and *Spodoptera*.
- The breeding lines PBS 23003, 24005, 24006, 24030, and 24040 showed resistance to thrips and PBS 23003 was resistant to both thrips and aphids. Two mutants derived from Grinar 1, PBS 30001 and TSP 60 showed resistant to the storage pest bruchid beetle and PBS 3000, which had 13% male yield over the best JL 24was also resistant to bruchid beetle.
- The genotypes PBS 21063, 23003, 24004, 24040, and FSD 66 were identified as tolerant of iron chlorosis. Four genotypes viz., FSD 7, FSD 36, FSD 46, and FSD 68, which were derived form the cross GAUG 1x GG 2 retained 75 per cent seed germination even after 15 months of storage under ambient condition after summer harvest.
- A varietal blend of three cultures did not perform better than the constituent cultivars under either moisture stress or under normal conditions.
- Lemon yellow leaf mutant trait was governed by a monogenic recessive gene and the gene symbol *Ly* (Green) and *ly* (lemon yellow) were proposed. The culrly leaf trait in groundnut was governed by a recessive gene. The gene symbols *lClm lClm* (normal) and lclm lclm (curly leaf mutant) have been proposed. The main axis flowering trait was laid to be goverened by two sets of duplicate genes interacting in duplicate epistatic manner. The pod size trait was laid to be controlled by two sets of duplicate loci interacting together with epistasis between loci in the parents studied. Two sets of duplicate genes *P1/p1*; *P2/p2* and *Q1/q1*; *Q2/q2* are proposed for pod size.
- A simple and fast method of screening groundnut genotypes for tolerance to lime-induced iron-deficiency chlorosis has been established using the chlorophyll meter (SPAD-502 Minolta, Japan).
- Genomic DNA was isolated from two samples each from each of 70 released cultivars, purified, estimated and stored for the fingerprinting and further characterization.
- Twenty-four crosses with ten marker genotypes were attempted and the probable hybrid pods were harvested with the objective of identifying morphological marker genes suitable for marker-aided selection.

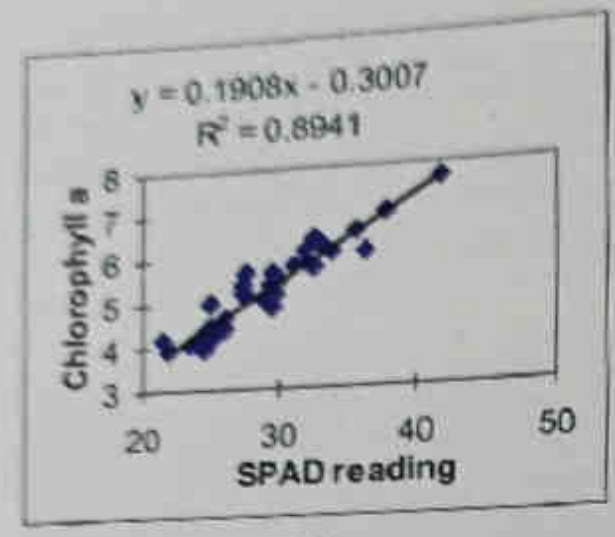
- INM in groundnut + castor system fetched about Rs.3,600/ha higher gross returns.
- Use of integrated pest management which included components like seed treatment, spray of neem oil, biocontrol agent, soil amendment with castor cake, barrier crop and pheromone traps gave about 21% higher pod yield of groundnut than farmers' practice in verification trials. In a farm trials management of the important soil borne diseases, stem & collar rot, application of castor cake @ 1 t/ha gave 62% control of collar rot and a similar control for stem rot.
- Farmers' training was organised.

C. Human resource development

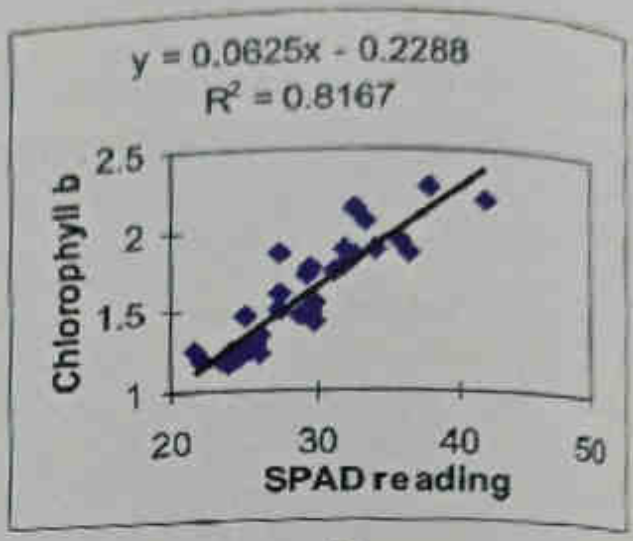
- Eleven personnels have participated in seminars/training progrmmes during the period.

D. Development & Administration

- Fifteen technical personnel of NRCG were promoted 10 of them to the next higher grade and 5 of them got the benefit of advance increment.
- Four scientists got promoted to the post of senior scientists by direct recruitment at the Centre.
- Twelve residential quarters, 6 each in type III and type IV category were constructed & allotted to the employees.
- All the rusted iron electric poles was replaced with reinforced cement concrete ones.
- A computer package for GPF in Excel/Access softwares was designed and tested.



(a)



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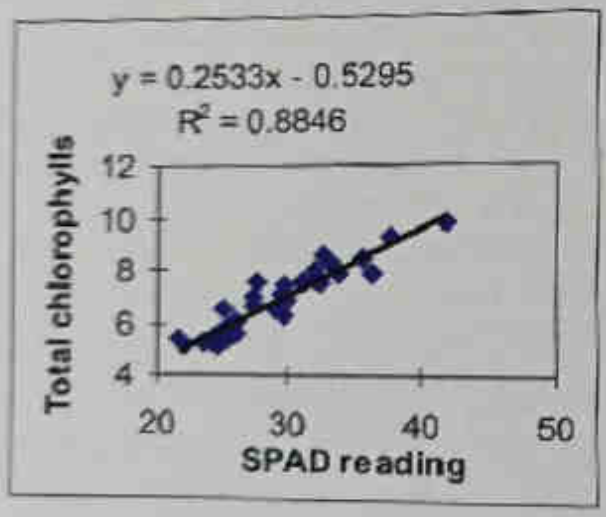

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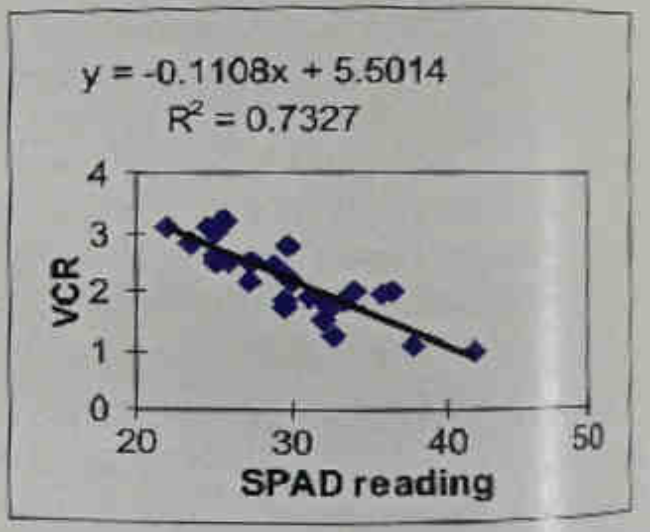


(d)

Figure 2. Relationships between (a) SPAD reading and chlorophyll 'a' (mg/g) content; (b) SPAD reading and chlorophyll 'b' (mg/g); (c) SPAD reading and total chlorophyll (mg/g); (d) SPAD reading and visual chlorotic rating (VCR), y=predicted value of chlorophyll content and VCR, and x=SPAD reading

Note : *The numbers referred by PBS are mutants and selections from intra-specific derivatives, and by Code are Inter-specific derivatives.*

Table:1. Population of sucking insects per 5 sweeps in IPM (Rabi-99)

Module	Jassids /5 sweeps				Thrips /5 sweeps			
	45DAS		90 DAS		45 DAS		90 DAS	
	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray	Pre-spray	Post-spray
M1	23.50	7.75	6.00	2.25	8.50	5.75	6.50	6.00
M2	17.75	5.25	6.25	2.00	7.50	4.00	10.25	8.50
M3	29.75	13.25	7.00	6.00	8.50	11.00	8.00	17.50
CD (p=0.05%)	8.55*	3.23**	NS	2.61*	NS	3.51*	2.76*	3.27**

CNO: Crude neem oil ; ETL : Economic Threshold Level; DAS: Days After Sowing
M1: 2% CNO in Teepol (based on ETL); M2: 2% CNO in Teepol (based on ETL)+ Pheromone traps for *Spodoptera*, *Helicoverpa* and leaf miner + repellant crop (pearl millet in the border) ; M3: Control (Farmers' practice)

Table: 2. Yield of groundnut and repellant crop in IPM (Rabi-99)

Module	Groundnut (kg/ha)	Pearl millet (kg/ha)
M1	2627	40
M2	1768	
M3	2727	

CNO: Crude neem oil ; ETL : Economic Threshold Level; M1: 2% CNO in Teepol (based on ETL); M2: 2% CNO in Teepol (based on ETL)+ Pheromone traps for *Spodoptera*, *Helicoverpa* and leaf miner + repellant crop (pearl millet in the border); M3: Control (Farmers' practice)

A. 2. IPM module for the rainy season.

In the rainy seasons season the crop was sown on 6.7.1999 and the crop was harvested on 11.10.1999. The thrips population load was very high. Spray of CNO at 2% was found to be sufficient to contain jassids and thrips (Table 3) which were on a par with repeated sprays using synthetic pesticides at 10-day intervals. Similarly, thrips eggs were also similar in the plots where 2% CNO was sprayed twice at 20-day intervals and spray of synthetic pesticides at 10 days interval (9 eggs/leaf) (Table 4). Since there was control to a considerable extent due to the trapping of *S. litura* population, foliage damage was at a level which cannot cause yield loss. The pheromone traps for *S. litura* trapped 539 males with a mean of 60 males/trap/week There was no males *H. armigera* trapped during the whole of the crop period. The IPM module which included trap crops (soyabean as intercrop, castor as border crop & pigeon pea as intercrop) + pheromone traps for *Spodoptera*, *Helicoverpa* and leaf miner + 2% Crude Neem Oil in Teepol (based on ETL) gave the highest gross return of Rs 21103/ha compared to the farmers practice (Rs 9540/ha) (Table 5).

Table 3. Population of sucking insects in IPM (Kharif 1999)

Module	Jassids per 5 sweeps								Thrips per 5 sweeps			
	First spray (20 DAS)		Second spray (30 DAS)		Third spray (55 DAS)		Fourth Spray (75 DAS)		First spray (20 DAS)		Second spray (30 DAS)	
	pre	post	pre	post	pre	post	pre	post	pre	post	pre	post
M1	8.75	6.50	9.50	5.00	10.27	5.97	6.02	2.90	6.50	5.25	18.00	8.50
M2	9.00	4.50	18.75	5.00	12.37	9.02	5.47	3.12	15.00	7.75	11.25	4.25
M3	10.5	2.75	17.25	4.00	7.50	7.19	4.90	1.72	24.50	7.75	15.00	1.75
CD (p=0.05%)	NS	1.81**	3.60**	NS	NS	NS	NS	1.47*	NS	NS	NS	3.11*

CNO: Crude neem oil ; ETL : Economic Threshold Level ; DAS: Days After Sowing M1: 2% CNO in Teepol (based on ETL); M2: 2% CNO in Teepol (based on ETL)+ pheromone traps for *Spodoptera* , *Helicoverpa* and leaf miner + trap crops (soyabean as intercrop, castor as border crop & pigeon pea as intercrop); M3: Control (Farmers' practice)

Table 4. Number of eggs of thrips per leaf in IPM (Kharif 1999)

Module	First spray (20 DAS)		Second spray (30 DAS)		Third spray (55 DAS)		Fourth spray (75 DAS)	
	pre	post	pre	post	pre	post	pre	post
M1	24.50	26.62	32.40	17.62	14.10	11.10	9.50	9.12
M2	27.27	23.02	29.35	18.25	14.80	12.55	17.65	8.65
M3	22.52	21.75	31.40	22.17	19.10	12.22	14.75	9.50
CD (p=0.05%)	NS	NS	NS	9.60*	NS	NS	NS	NS

CNO: Crude neem oil ; ETL : Economic Threshold Level ; DAS: Days After Sowing M1: 2% CNO in Teepol (based on ETL); M2: 2% CNO in Teepol (based on ETL)+ pheromone traps for *Spodoptera*, *Helicoverpa* and leaf miner + trap crops (soyabean as intercrop, castor as border crop & pigeon pea as intercrop); M3: Control (Farmers' practice)

Table 5 Yield (kg/ha) and return (Rs) in IPM (Kharif 1999)

Module	Groundnut*	Soybean	Castor	Redgram	Gross(Rs)
M1	577.78 (9621.78)				9621.78
M2	235.80 (3356.80)	141.42 (1414.20)	63.64	897.16	21107.79
M3	690.12 (9540.30)	----	----	----	9540.30
CD (p=0.05%)	174.32**				3709.55**

CNO: Crude neem oil ; ETL : Economic Threshold Level M1: 2% CNO in Teepol (based on ETL); M2: 2% CNO in Teepol (based on ETL)+ pheromone traps for *Spodoptera*, *Helicoverpa* and leaf miner + Trap crops (soyabean as intercrop, castor as border crop and pigeon pea as intercrop); M3: Control (Farmers' practice)

Table 3: Mean SPAD reading, VCR, Chlorophyll 'a', chlorophyll 'b', and total chlorophyll content (mg/g dry weight basis), and pod yield in tolerant advanced breeding genotypes of groundnut.

Entry Name	Pedigree of the genotypes	SPAD Reading	VCR	Chloro-phyll 'a'	Chloro-phyll 'b'	Total Chloro-phyll	Pod Yield (g/plant)
PBS 21063	M 13 x NCAc 17278	37.85	1.08	6.94	2.27	9.21	5.13
PBS 23003	RSB 87 x CGS 101	31.98	1.50	6.12	1.88	8.00	9.17
PBS 24004	Latur 33 x Tifrun	32.59	1.25	6.42	2.13	8.55	11.25
PBS 24040	Latur 33 x Tifrun	35.71	1.92	6.54	1.94	8.48	7.96
FSD-66	GAUG 1 x GG 2	33.25	1.83	6.23	2.06	8.29	10.99
PBS 20100 (RC)	-	41.83	1.00	7.67	2.19	9.85	9.31
PBS 20101 (SC)	-	24.28	3.00	4.26	1.26	5.52	8.20
PBS20511 (SC)	VRI 3	24.05	3.18	4.06	1.18	5.24	6.79
PBS 20055 (SC)	ICG 7867	21.53	3.58	4.17	1.25	5.42	10.22

RC- Resistant check, SC- Susceptible check

D. Studies on varietal blending with reference to yield

In summer 1999, a trial on varietal blend was taken up with five cultivars ALR 2, GG 2, JL 24, SB XI, and TG 26 and their all ten possible combinations, each containing three varieties each represented by an equal number of seeds. The trial was conducted in two conditions (one irrigated and the other with induced moisture stress from 40 to 65 days after sowing) arranged in split plot design with two replications. There was significant difference for 100-pod weight, 100-seed weight, shelling percentage, pod yield/ha and kernel yield/ha. Under both the situations none of the blends out yielded the best check GG 2 in any of the two situations. The yield levels of blends more or less followed the level of cultivars constituting the blend.

E. Testing of advanced breeding cultures for longer viability of seed grown in rabi-summer season

Seventy-four Spanish advanced breeding cultures (F7 generation) developed from the cross GAUG 1 X GG 2, which were made for longer seed viability and fresh seed dormancy, were multiplied during the summer of 1998 and stored in gunny bags under normal room condition. The germination test was conduced for assessing the seed viability after 10, 12 and 15 months of storage. The breeding lines FSD 7, FSD 36, FSD 46, and FSD 68 with good seed viability (>75% germination) were identified even after 15 months of storage as compared to the parent GG 2 (<5% germination).

F. Basic experiments

F. 1. Genetics of EMS induced lemon yellow leaf mutant (Girnar 1 lym)

Chemically induced lemon yellow leaf mutant of Girnar 1 (fig 1) was crossed with the parent (Girnar 1). All the F1 had normal green foliage like Girnar 1 for the entire plant growth. A good fit to 3 (green): 1 (lemon yellow) leaves ratio was found in F2. Hence, it could be concluded that the mutant in question is a monogenic recessive one. The gene symbols *Ly* (Green) and *ly* (lemon yellow) were proposed.

Fig 1. Girnar1 and Girnar1 lym lemon yellow mutant) of leaf

F. 2. Genetics of Curly leaf mutant (Girnar 1 clm)

Girnar 1clm, a curly leaf mutant was crossed with the parent Girnar 1. All the F_1 plants were with normal foliage. In F_2, the progenies gave a good fit to the 3 normal: 1 curly leaf ratio. The gene symbols *lClm lClm* (normal) and *lclm lclm* (curly leaf mutant) have been proposed.

F. 3. Genetics of main axis flowering

The genotypes with main axis flowering (MAF) Chico and Girnar 1 were crossed with three Virginia cultivars- CSMG 84-1, GAUG 10 and ICGV 86325. The F1's of all the six crosses did not have main axis flowering. In F2, segregation of main stem flowering varied with the families in both male and female parents used in the crosses. Chico as a male parent produced 9:7; 225:31; and 3:1 ratios with ICGV 86325, CSMG 84-1 and GAUG 10 as female parents, respectively. Similarly, Girnar 1 as male parent exhibited 3:1 ratio with ICGV 86325 and CSMG 84-1 as female parent. The same male parent (Girnar 1) again produced 225:31 (7:25:1) ratio with GAUG 10 as female parent. It was clear that the genotypes of both male parents, Chico and Girnar 1, were different as they produced different F2 ratios when the same set of female parents were used in the crosses. Similarly, all the female parents exhibited different F2 ratios against common male parents. Thus, it may be concluded that all the male parents and so also the female parents used in this study were genotypically different from one another with respect to main stem flowering. Thus, using the gene symbols proposed by Hammons (1973), the possible genotypes of these five parents used in this study could be *j1 j1 J2J2 K1K1 k2k2* (ICGV 86325); *J1J1 J2 J2 K1K1 K2K2* (CSMG 84-1); *J1J1 J2J2 k1k1 K2K2* or

D. 2. Screening for resistance to thrips and aphids (in net house)

The advanced breeding cultures PBS 23003, 24005, 24006, 24030, and 24040 showed resistance to thrips, since they had the least number of thrip's eggs (0.55 to 1.99) as compared to the check cultivars GG 2 (5.2) and JL 24 (8.9).

D. 3. Screening for Resistance to Bruchid beetle

Mutants of Girnar1 were screened under laboratory condition for resistance to Bruchid beetle infestation, a deadly storage pest of groundnut. Two mutants PBS 30001 and TSP 60 have been identified as resistant to bruchid beetle infestation.

Sub-project 2: Breeding and gentic studes on abiotic stresses in groundnut
(R.K.Mathur, P. Manivel, M.Y. Samdur, A.L. Singh and P.C. Nautiyal)

A. Hybridization

A total of 42 crosses were made during kharif 1999. Out of which 15 were for study of the genetics of specific leaf area (SLA), a character related to water use efficiency and 15 for incorporation of tolerance to iron chlorosis.

B. Multiplication, generation advancement and selections

A total of 580 genotypes comprising advanced breeding cultures (98), aluminum toxicity tolerant lines (8), and cultivars (31) were multiplied for further use. Sixty-two advanced breeding cultures were selected for further evaluation and 10 genotypes were selected as parents for fresh hybridization. In the segregating generations, 45 crosses in F1, 36 crosses in F2, 38 crosses in F3, 10 crosses in F4, and 8 crosses in F5, generations were advanced.

C. Preliminary yield evaluation of advanced breeding cultures

A total of 70 advanced breeding cultures belonging to the Spanish and Virginia types were evaluated along with six check cultivars viz., Girnar 1, GG 2, TG 26, JL 24, Kadiri 3 and ICGS 44 in a replicated trial. Twenty-two cultures were selected for further testing.

C. 1. Screening of advanced breeding cultures for tolerance to iron chlorosis:

Thirty advanced breeding lines were screened for tolerance to iron-deficiency-chlorosis the during summer 1999. The genotypes PBS 21063, 23003, 24004, 24040, and PSD 66 were categorized as tolerant and had 9.21, 8.00, 8.55, 8.48, and 8.29 mg/g total chlorophyll and 37.85, 31.98, 32.59, 35.71, and 33.25 SPAD reading, respectively (Table 3). SPAD meter readings have been reported (section C.2) to have high positive correlation with chlorophyll content and negative correlation with visual chlorotic rating (VCR) on 1 to 5 scale (1=highly resistance and 5= highly susceptible). However, tolerance and yield were not correlated.

PROJECT 01: BREEDING AND GENETIC STUDIES ON BIOTIC AND ABIOTIC STRESSES IN GROUNDNUT

Sub-Project 1: Breeding and genetic studies on biotic stresses in groundnut

(M.Y. Samdur, R.K.Mathur, P. Manivel, M.P. Ghewande, and V. Nandagopal)

A. Hybridization

Four fresh crosses for incorporation of resistance to late leaf spot (LLS) and 20 crosses (male in 5lines x 4 tester design) to study genetics of resistance to collar rot were made during kharif 1999.

B. Multiplication, generation advancement and selections

A total of 407 genotypes comprising advanced breeding cultures (56), mutants (163), interspecific cross derivatives (26) and germplasm lines (182) were multiplied. Twenty advanced breeding cultures were selected for further evaluation and 9 genotypes were selected as parents for fresh hybridization. In the segregating generation, 24 crosses in F1, 18 crosses in F2, 13 crosses in F3, 9 crosses in F4, and 10 crosses in F5, generations were advanced.

C. Yield evaluation trials

Two yield evaluation trials, i) with 25 spanish (*Arachis hypogaea spp. fastigiata* var. *vulgaris*), and ii) with 12 virginia (*Arachis hypogaea* spp. *hypogaea* var. *hypogaea*) cultures were conducted in rainfed condition

In the first trial, mutant of Girnar 1, PBS 30001 recorded 13% increase in yield over the best check JL 24. This mutant was also found to be resistant to storage pest bruchid beetle.

In the second trial, the cultures PBS Nos. 24009, 21046, 22028, and 24005 were found superior over the best check ICGS 44 for kernel yield (Table 1). The culture PBS 24009 had shown a significant yield increase of 46% over the best check.

D. Field screening for resistance to diseases and insects

D. 1. Screening for collar rot, late leaf spot (LLS) and rust resistance

The cultures PBS Nos. 13013, 14026, 18004, 21063, 22017, 22026, 24009, 30016, 30021, Code 7, Code 11, Code 26 and CS 19 showed moderate resistance to collar rot and showed below 5% disease incidence (maximum incidence of 30% was found in ICGV 89211) under field screening. The cultures, which showed scores below 3 for LLS and rust on a 1-9 scale (1= highly resistant, 9= highly susceptible), are presented in the table 1. The cultures PBS 11048 and PBS 11057 (both from the cross Dh 3-30 x NCAc 2230), PBS 22011(derived from Latur 33 x PI 275750), and PBS 30138 (Chemically induced mutant of Girnar 1) showed resistance to both LLS and rust.

recessive homozygote for any one of *j* or *k* loci (GAUG 10: *j1j1 j2j2 k1k1 k2k2* (Chico); and *j1j1 J2J2 k1k1 k2k2* or dominant homozygote for any one of the *j* or *k* loci (Girnar 1). All the F2 ratios observed in the present study (3:1; 9:7; and 225:31) could be explained very conveniently assuming the proposed genotypes of the parents. Since the segregation pattern and the gene action observed in the present study were in conformity with those of earlier workers hence the gene symbol need not to be changed.

F. 4. Genetics of pod size

Two Spanish cultivars- GG 2 small pod size (as female parent) and NRCG 1339 large pod size (as male parent) were crossed and the F1 and F2 generations were studied for pod size. Large size of pod was dominant over small size. In F2 the ratio 170 plant with large size pods: 24 plants with small size pods had a good fit to the ratio of 225:31 (~7.25:1), thus, indicating control of two sets of duplicate loci interacting together with epistasis between loci. Two sets of duplicate genes *P1/p1*; *P2/p2* and *Q1/q1*; *Q2/q2* are proposed for pod size for this pair of parents.

F. 5. Use of chlorophyll meter for screening genotypes tolerant of iron-deficiency chlorosis:

The advanced breeding cultures tested for tolerance to lime-induced iron-deficiency chlorosis were used in studying use of SPAD meter as a surrogate for screening for tolerance. The first fully opened leaves of main axis, from 10 randomly selected plants of each genotype were collected and reading were taken on them using meter (SPAD 502 Minolta, Japan) and also chlorophylls 'a' and 'b'and total chlorophyll content (dry weight basis) were also colorimetrically estimated at 30, 45, 60, and 75 days after emergence (DAE).

Correlation coefficients (r) and regression equations between SPAD reading and chlorophyll contents and VCR are presented in fig 1. Correlation coefficients between SPAD readings and chlorophyll content were highly significant at all the stages of sampling. Over the mean of four samples recorded at 30, 45, 60 and 75 days after emergence (DAE), the 'r' values between SPAD reading and chlorophyll content were 0.94 for chlorophyll a, 0.90 for chlorophyll b and 0.93 for total chlorophyll, indicating a close relationship of these traits with SPAD reading ie., the higher the SPAD reading higher the chlorophyll content and *vice-versa*. The regression lines (Figure 2) showed that these variables are linearly related with each other. On the basis of the linear relationship, regression equations were developed. The tolerant genotypes showed SPAD reading more than 30 and total chlorophyll (TC) content more than 8.0 mg/g dry weight of leaves and VCR below 2.0. On the other hand genotypes with SPAD reading below 25.0 had TC content less than 6.0 mg/g, and VCR more than 2.75 were sensitive to iron chlorosis.

Table 1. Yield and other characteristics of promising Spanish and Virginia advanced breeding cultures identified from In-station yield evaluation trials.

Name of the culture	Pedigree	Seed yield (kg/ha)	Increase over the best check (%)	SP	HSW	Special features
Spanish						
PBS 30001	Mutant of Girnar 1	775	13	75	36	Resistant to bruchid beetle
JL 24	Best Check	689	--	76	49	
Virginia						
PBS 24009	CGC 7 x JL 24	1031*	46	76	41	Moderately resistant to jassids & thrips
PBS 21046	ICGS 11 X Ah 7666	904	28	71	47	Moderately resistant to rust, very early (105 days)
PBS 22028	M 13 x NCAc 17500	876	24	69	52	Moderately resistant to rust
PBS 24005	M 13 x Robut 33-1	814	15	72	46	Moderately resistant to jassids & resistant to *Alternaria* blight
ICGS 44	Best Check	707	--	76	43	

SP = shelling per cent and HSW = Hundred seed weight

* Significantly higher than check at 5%

Table 2. List of resistant cultures (in field conditions)

Diseases	Resistant (Score <3)
Late leaf spot Susceptible check PBS 11019 (Score 9 on 0-9 scale)	PBS Nos. 11048, 11057, 12066, 22005, 22011, 22026, 22028, 23026, 24037, 30043 & 30138
Rust Susceptible check PBS 11029 (Score 9 on 0-9 scale)	PBS Nos.11048, 12032, 11057, 12056, 12074, 21013, 22005, 22011, 23019, 29021, 29039, 30005, 30012, 30013, 30051, 30084, 30085, 30098, 30102, 30108 & 30138
Insects	
Spodoptera & Helicoverpa Susceptible check PBS 12120 (Score 9 on 0-9 scale)	PBS Nos.11042, 12097, 12117, 12115, 21030, 21043, 21046, 21063, 22006, 22015, 23003, 24030, 24057, Code 9, Code 26 and JCA 19-B-2-5B

The culture PBS 23019 (a derivative from the cross Chandra x NCAc 343) was found to be resistant to rust, and moderately resistant to LLS and *Helicoverpa/ Spodoptera*.

PROJECT 02: IPM FOR GROUNDNUT BASED PRODUCTION SYSTEM

Sub-Project 1: Integrated Insect Pest Management of thrips and defoliators in groundnut using non- synthetic pesticides, biocontrol agents and cropping system approach (V. Nandagopal)

A. Development of IPM module

The project aims at development of IPM system in groundnut by integrating feasible components of management tactics excluding synthetic pesticides, to derive the maximum benefit of IPM, causing least possible harm to the environment and food chain.

A. 1. IPM modules for irrigated groundnut grown in the summer season.

During the summer season of 1999 the crop was sown on 22.2.1999 and the crop was harvested on 8.6.1999. The pest load was limited to the sucking insects. The components of the IPM were tried individually as well as in combination in the earlier studies. Based on their performance, those components of IPM found to be successful during the rainy season such as Economic Threshold Levels (ETL) based application of 2% crude neem oil (CNO) (in Teepol), pheromone traps for *Spodoptera litura*, *Helicoverpa armigera* and *Aproaerema modicella* and a repellent crop like bajra against thrips were used in the IPM module and compared with farmers' practice. ETL for Thrips and Jassids is 5 insects/terminal leaf and 175 insects/5m row at vegetative and pod filling and 385 jassids at maturity The population of the jassids (*Balclutha hortensis* Lindb.), at the post spray observation was significantly less both at 45 days after sowing (DAS) (7.8 numbers/5 sweeps) and at 90 DAS (2.3 numbers/5 sweeps) when 2% CNO was sprayed compared to the farmers' practice (13.3 and 6 numbers/5 sweeps respectively) where four sprays of synthetic pesticides namely 0.04% monocrotophos at 30 DAS, 0.03% phosphamidon at 45 DAS and repeated both the insecticides on 65 DAS and 90 DAS (Table1). Similarly the thrips population of post spray observation were 5.8 and 6, respectively on 45 DAS and 90 DAS compared to 11 numbers/5 sweeps and 17.5 numbers/5 sweeps, respectively in the farmers practice. There was some control of the defoliators due to trapping of the wild males using the pheromone trap (823 males of *Spodoptera litura* and 130 males of *Helicoverpa armigera*, with a mean of 91 and 14/ week, respectively) which resulted below 1% foliage damage which cannot cause yield loss in groundnut. Almost similar pod yields were obtained from those plots which received only two sprays of CNO (2627 kg of pod/ ha) as the plots which received four sprays of synthetic pesticides, as above (2727 kg / ha). When the IPM module (2% CNO) + Pheromone traps for Spodoptera, Helicoverpa and leaf miner + repellant crop (pearl millet in the border) was followed, the yield of groundnut was only 1768 kg/ha due to the loss of two rows of groundnut which was replaced by the pearl millet (Table 2).

Table 9-B. Evaluation of some released cultivars and crossed derivatives for dry seed resistance to collar rot pathogen (*A. niger*) under artificial inoculation

Sr. No.	Genotype	Mena Seed Infestion (%)	Mena Seed Colonisation (%)
1	JL 24 X J 11	0.010	6.67
2	R 33-1 X J11	6.670	3.34
3	GAUG 10 x J 11	55.703	32.85
4	GG 13 x J 11	36.67	6.67
5	GG 20 x J 11	13.14	3.34
6	JI 24 x ICGV 87260	3.34	0.01
7	R33 -1 x ICGV 87280	3.34	0.01
8	GAUG 10 x ICGV 87280	56.66	21.00
9	GG 13 x ICGV 87280	56.66	30.00
10	GG 20 x ICGV 87280	30.00	26.67
11	JI 24 x ICG 899	13.33	6.67
12	R 33-1 x ICG 899	3.34	0.01
13	GAUG 10 x ICG 899	33.33	13.33
14	GG 13 x ICG 899	60.00	50.00
15	GG 20 x ICG 899	36.67	26.67
16	JI 24 x ICG 3001	36.67	26.67
17	R 33-1 x ICG 3001	16.67	16.67
18	Sandhadi	6.67	6.67
19	TKG 19 A	33.33	23.33
20	GG 20 x ICG 3001	35.71	13.33
21	ICGV 87280	30.00	10.00
22	JI 24	33.33	23.33
23	GG 20	33.33	16.67
24	J 11	13.33	6.67
	CD at (0.05%)	35.52	25.46
	CV %	79.74	100.03

TABLE 2 CONTD...

Eupatorium leaf powder + Karanj leaf powder	38.04	45.65	37.67	9.71	1512.76	----	----	----	----	----
Neem seed powder + T. viride	43.18	51.53	40.04	11.41	1413.99	----	----	----	----	----
PGP Bacterial spp. (Shakti sd) 4 G./Kg. seed	----	----	----	----	----	30.33	33.52	46.46	6.89	687.41
Trichoderma spp. (Star t) 4G./Kg. seed	----	----	----	----	----	31.25	32.78	40.62	4.80	725.15
Shakti sd 4 G /Kg. seed+soil application of star-t 6.25 Kg./Ha.	----	----	----	----	----	30.49	30.03	40.36	7.52	568.89
Control	42.12	34.27	38.78	23.85	1234.57	37.52	39.23	53.86	9.34	760.00
C.D (0.05%)	4.52	8.94	4.61	7.09	N.S.	N.S.	N.S	N.S.	N.S	N.S

Table-11. Effect of soil organic amendment on the development of diseases and yield of groundnut during Kharif 1998-1999

Treatment	Kharif 1998					Kharif 1999				
	Disease Intensity(%)				Yield (kg/ha)	Disease Intensity(%)				Yield (kg/ha)
	ELS	LLS	Rust	Stem Rot(%)		ELS	LLS	Rust	Stem Rot(%)	
Castor cake 1000 Kg./ Ha.	30.95	35.66	30.76	20.04	1328.40	23.09	22.86	30.72	5.36	583.30
Neem cake 1000 Kg./Ha.	33.02	36.94	36.20	21.72	1224.69	28.56	23.31	39.16	7.71	767.79
Mustared cake 1000 Kg./Ha.	27.61	32.40	27.90	22.54	1364.20	22.92	20.72	31.04	3.68	854.42
Castor cake 500 Kg./Ha. + neem cake 500 Kg./Ha.	30.26	37.19	31.45	26.15	1249.38	30.63	27.23	42.03	6.21	734.41
Control	32.92	41.22	33.83	29.26	1214.81	32.38	29.43	45.50	8.94	875.26
C.D. (0.05%)	2.77**	4.98*	4.48*	N.S.	N.S.	5.56*	N.S.	7.08*	5.41*	62.59

Table 9-A. Evaluation of some advanced breeding lines for dry seed resistance to pathogen (*A. niger*) under artificial inoculation

Sr. No.	Genotype	Mena Seed Infestion (%)	Mena Seed Colonisation (%)
1	PBS 20026	40.00	40.00
2	PBS 20053	40.00	40.00
3	PBS 20501	43.33	43.33
4	PBS 21020	50.00	53.33
5	PBS 21063	60.00	63.33
6	PBS 23007	43.33	40.00
7	PBS 24001	66.33	53.33
8	PBS 24002	33.33	30.00
9	PBS 24003	20.00	23.33
10	PBS 24006	33.33	43.33
11	PBS 24040	46.46	43.33
12	PBS 29022	53.33	46.66
13	PBS 29030	53.33	73.33
14	CODE-11	56.66	50.00
15	CODE-12	26.66	56.66
16	CODE-13	40.00	40.00
17	PBS 24030	96.66	56.66
18	PBS 24004	83.33	50.00
19	PBS 11046	53.33	56.66
20	CS 19	40.00	33.33
21	PBS 24005	56.66	43.33
22	CODE -7	53.33	43.33
23	PBS 20502	40.00	33.33
24	PBS 24009	50.00	36.66
25	CODE-30	36.66	20.00
26	PBS 24041	23.33	50.00
27	PBS 21050	60.00	43.33
28	PBS 22028	63.33	30.00
29	CS-21	50.00	36.66
30	MOR 234	53.33	36.66
31	PBS 11023	66.66	43.33
32	PBS 21013	96.66	96.66
	C.D.(0.05%)	28.28**	27.91**

mass trapping and monitoring leaf miner in groundnut and this technology can be used in soybeans also.

Sub-Project 2 : Integrated Management of major disease (ELS, LLS, Rust, Collar rot, Stem rot and PBND) of groundnut

(M.P. Ghewande)

A. Disease resistance

Field and laboratory evaluation of some released cultivars and advanced breeding lines was done for resistance to early leaf spot (ELS), late leaf spot (LLS),rust, collar rot (*Aspergillus niger*)and stem rot (*Sclerotium rolfsii*).

Out of 32 genotypes screened against resistance to seed infection and seed colonization by Aspergillus niger in the laboratory, two breeding lines namely Code 30 and PBS 24003 were moderately resistant to seed colonization by *A.niger* (Table 9-A). In another set, 18 cross derivatives in F1 generation along with some released varieties and advanced breeding lines were also screened for resistance to seed colonization by *A.niger*. Cross derivates of JL 24 x ICGV 87280, R-33-1 x ICGV 87280, R-33-1 x ICG 3001 R-33-1 x ICG 899 were found to be highly resistant. Other cross derivatives, JL 24 x J11, R-33-1 x J11, GG13 x J 11, GG 20 x J11, JL 24 x ICG 899, and JL 24 x ICG 3001 were found to be resistant to seed colonisation by *A. niger*. Among the advanced breeding lines,ICGV 87280, PPS-5 and released cultivers ICGV 86594 and J 11 were found to be resistant to seed colonization by *A.niger*. (Table 9-B).TKG 19 A and J11 were resistant to seed colonization by *A. flavus*. (Table 9-C)

B. Disease Management

B. 1. Seed treatment

Seed treatment with 2% by weight dry leaf powder of *Euphorbia sp.* + *Pongamia pinnata* and/or 2% neem seed powder + *Trichoderma viride* @ 4g/kg seed gave maximum (47-59%) control of stem rot and realized higher yields (1414-1513 Kg/ha) during kharif 1998. However, during 1999, seed treatment with Trichoderma sp.and *T. harzianum* @ 4 g/ kg seed was found to be the best which gave 49% control of stem rot. (Table-10)

B. 2. Organic Soil amendment

During kharif 1998 soil application of mustard cake @ 1000kg/ha reduced ELS by 16.32%,LLS by 21.34% and rust by 17.52%. The incidence of stem rot was reduced by 31.51% in castor cake treatment followed by neem cake and mustard cake. The maximum yield of 1364 kg/ha was obtained in mustard cake treatment followed by castor cake. During kharif 1999,mustard cake reduced ELS by 29.21% and castor cake reduced ELS by 28.69 %. Mustard cake and castor cake reduced rust by 32%. The stem rot

Table-13. Effect of foliar application of bio-control agents and botanical fungicides on disease development and yield of groundnut during kharif 1998-1999

Treatment	Kharif 1998					Kharif 1999					MEAN OF 2 YEARS				
	Disease Intensity(%)				Yield (kg/ha)	Disease Intensity(%)				Yield (kg/ha)	Disease Intensity(%)				Yield (kg/ha)
	ELS	LLS	Rust	Stem Rot(%)		ELS	LLS	Rust	Stem Rot(%)		ELS	LLS	Rust	Stem Rot(%)	
P. islamdicum C.F.	36.93	47.58	38.09	12.57	1267.49	24.60	25.43	45.29	15.18	573.33	30.76	36.40	41.69	13.87	920.41
P. islamdicum spore suspension	35.17	40.66	31.77	12.48	1580.25	27.81	27.10	34.97	10.53	648.89	31.49	33.88	33.37	11.50	1114.57
T. harzianum	38.62	49.17	38.50	15.89	1366.26	23.19	25.48	30.08	11.64	718.52	28.40	37.32	34.29	13.76	1042.39
Foliar appl. of *T. harzianum* +soil appl. of *T. harzianum*	33.52	37.33	30.53	11.95	1316.87	30.01	33.70	45.85	8.99	788.15	31.76	35.51	38.09	10.47	1052.51
V. lecani C.F.	37.53	50.85	37.60	9.11	1711.93	36.02	34.33	50.52	10.70	715.56	36.77	32.59	44.06	9.90	1213.74
V. lecani (Spore suspnsion)	37.82	45.00	40.40	12.04	1465.02	31.44	35.38	48.77	13.39	690.37	34.63	40.19	44.58	12.71	1052.69
Neen seed kernel extract (5%)	42.99	46.64	33.09	12.18	1497.94	32.87	33.06	48.73	13.77	681.48	37.93	39.85	40.90	12.97	1089.71
Mustard cake extract (5%)	32.27	35.52	30.51	5.31	1580.25	35.38	31.59	42.25	15.50	777.78	33.82	33.55	36.38	10.40	1179.01
CARBENDAZIM 0.05 %+ MANCOZEB 0.2%	28.52	28.82	25.71	11.33	1497.04	23.95	22.36	35.76	10.67	794.07	26.23	25.59	30.73	11.00	1145.55
Control (Water spray)	44.62	57.99	42.71	16.85	1465.02	34.95	36.65	52.01	12.17	682.96	39.78	47.32	47.36	14.51	1073.97
C.D.(0.05%)	3.63**	6.31**	4.63**	N.S.	N.S.	5.49**	4.98**	7.87**	N.S.	N.S.	---	---	---	---	---

C. Monitoring of insects

The aphids were monitored using drum trap and sticky trap. The aphid (*Aphis craccivora*) density was the highest in January with 1229 aphids/trap/month in the drum trap and was 454 aphids /month in the sticky trap. Leaf miner was active throughout the year, but peaked (a low peak) in February and then steadily increased from September to December (Fig.2).

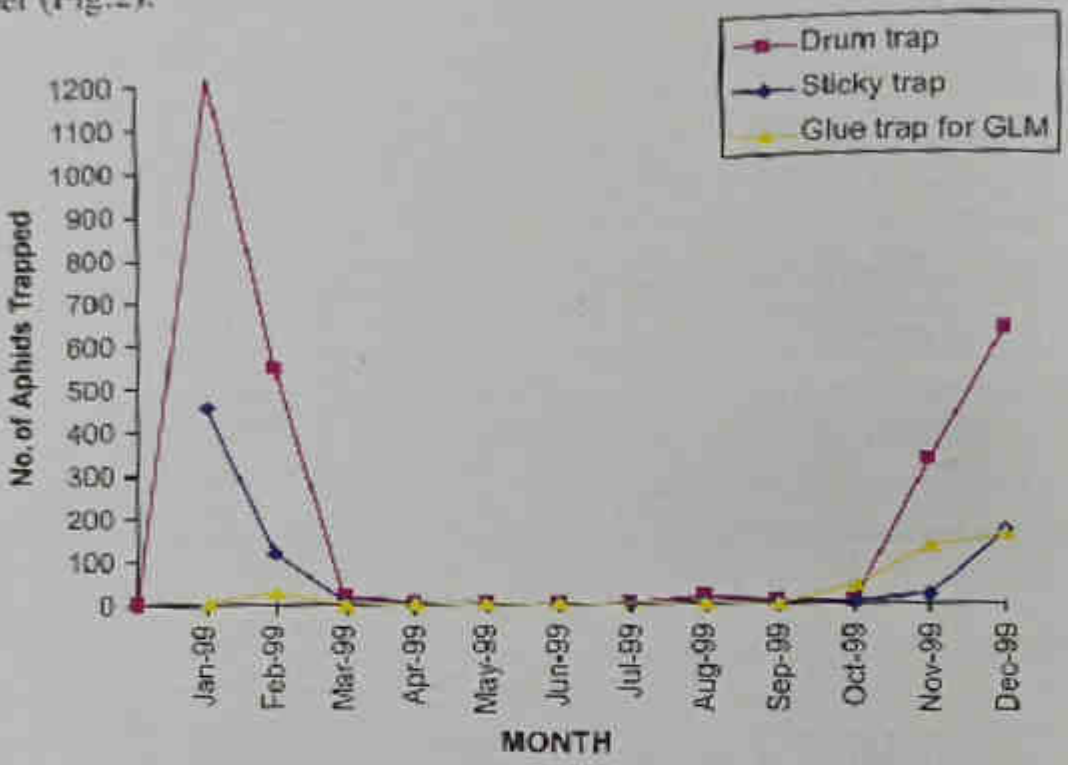


Fig 2. Monitoring of Insect Pest

D. Synthesis of sex pheromone and development of pheromone trap for groundnut leaf miner

The components of the sex pheromone of the groundnut leaf miner (*Aproaerema modicella* Dev.) were synthesized in collaboration with the Indian Institute of Chemical Technology (IICT), Hyderabad for the first time in India. The three components were the following,

(1) - (R)-(Z)-7,9-Decadienyl acetate (a 0 carbon acetate with two conjugated double bonds.

(2) - E7-Decenyl acetate and

(3) - Z7-Decenyl acetate

Its blend in the ratio of 10:20:14 were found efficient in trapping of the males of groundnut leaf miner. An efficient trap has also been fabricated and developed for

Table 9-C. Evaluation of some bold seeded genotypes for dry seed resistance to *Aspergillus flavus*

Sr. No.	Genotype	Mena Seed Infestion (%)	Mena Seed Colonisation (%)
1	JL 24 X J 11	0.010	6.67
2	TG 42	36.66	46.66
3	TG 41	23.33	26.66
4	TG 39	66.66	70.00
5	TKG 19 A	6.67	6.67
6	JSP 31	26.66	33.33
7	BAU 13	76.66	73.33
8	J 11	20.00	10.00
9	GG 2	20.00	23.33
	CD AT(5.05%)	21.40	27.96
	CV %	35.34	44.08

Table 10. Effect of seed treatment with bio-control agents and biofungicides on disease development and yield of groundnut during kharif 1998-1999

Treatment	Kharif 1998					Kharif 1999				
	Disease Intensity(%)				Yield (kg/ha)	Disease Intensity(%)				Yield (kg/ha)
	ELS	LLS	Rust	Stem Rot(%)		ELS	LLS	Rust	Stem Rot(%)	
T.viride (Monitor .P.) 4 G./Kg. seed	33.43	44.72	30.71	15.05	1570.37	32.27	31.42	45.29	9.11	677.04
T.harzianum 4 G./Kg. seed	33.30	39.49	31.41	14.28	1461.73	36.65	33.70	40.70	5.80	820.74
Neem seed powder 2 %	33.70	43.57	27.81	16.91	1119.22	31.62	32.78	38.40	6.18	837.04
Karanj leaf powder 2 %	31.78	38.65	27.07	20.68	1703.70	31.35	34.49	42.99	6.55	762.96
Neem leaf powder 2 %	33.27	41.30	30.76	19.84	1723.46	38.33	36.65	51.07	7.56	720.00
Carbendazim 2 G./Kg. seed	34.54	43.76	30.76	16.06	1456.79	32.25	38.34	45.59	7.10	774.81
Euphorbia leaf powder 2 %	31.60	36.68	30.08	12.58	1623.04	-----	-----	-----	-----	-----

resulted better seed germinability. In addition the pyramid shape structure with plants arranges as in a thatched house allowed the rain water to run-off quickly, which otherwise would have stuck to the pods, and such situation prevailed during the drying in second set in 1998.

A. 2. Electrical conductivity of seed leachate

Slow drying in NRCG and DOR methods helped in maintaining membrane integrity and higher germinability as understood from the values of EC of seed leachate, both collected immediately after drying and after nine months of storage (Table 1). These EC values of seeds were in general, higher in 1999 than the 1998 (1st set). During 1998 RH ranged between 34% and 84% in the first set, and 60% and 90% in the second set, whereas in 1999 it ranged between 50% and 88%. Thus the prevailing weather conditions during different drying periods influenced the rate of loss of moisture from the pods, which in turn affected the seed membrane integrity (as reflected by the EC values).

Table 1: Germination percentage and seedling vigour index (SVI) of the seeds obtained from the pods dried following four different methods, immediately after drying (0, months) and after 9 months of storage in two summer seasons (1998-99).

Drying methods	Germination (%)		Seedling vigour index (SVI)		Electrical conductivity of seed leachate (mSg-1)	
	Storage period (months)					
	0	9	0	9	0	9
Summer 1998 (first set)						
DOR-method	93	66	863	450	0.032	0.099
Windrow method	74	19	574	73	0.070	0.163
NRCG-method	98	82	1101	548	0.031	0.070
Conventional drying method	94	59	865	327	0.038	0.105
S.E.	3.18		39.13		0.005	
Summer 1998 (second set)						
DOR-method	92	49	728	271	0.052	0.107
NRCG-method	91	81	936	686	0.031	0.085
S.E.	4.10		44.2		0.007	
Summer 1999						
DOR-method	96	42	985	185	0.043	0.158
Windrow method	75	10	628	28	0.114	0.307
NRCG-method	95	52	1037	293	0.041	0.146
Conventional drying method	96	35	882	132	0.072	0.180
S.E	2.47		34.96		0.009	

Table 8. Measurement means of different stages of the bruchid beetle *C. serratus*

Stage	Length ± SD (mm)	Width ± SD (mm)
Egg	1.0 ± 0.03	0.6 ± 0.04
Larval instar		
First	1.8 ± 0.2	1.0 ± 0.04
Second	3.0 ± 0.3	1.5 ± 0.1
Third	4.4 ± 0.6	1.9 ± 0.2
Fourth	7.2 ± 0.8	2.5 ± 0.3
Pupa	5.2 ± 0.5	3.4 ± 0.3
Female	5.2 ± 0.2	3.0 ± 0.1
Male	5.7 ± 0.2	2.6 ± 0.1
Measurement of head capsule of different larval instars		
Larval instar		
First	0.31 ± 0.03	0.27 ± 0.02
Second	0.34 ± 0.01	0.33 ± 0.00
Third	0.55 ± 0.04	0.51 ± 0.02
Fourth	1.73 ± 0.02	1.70 ± 0.00

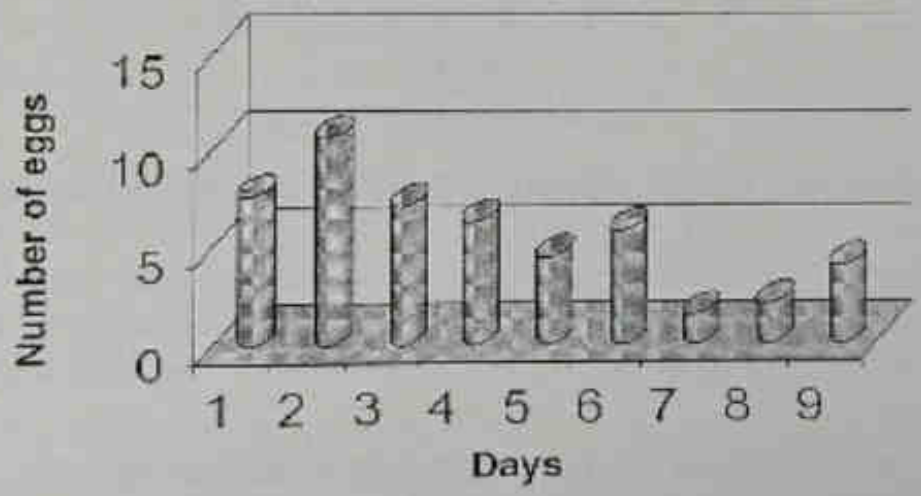


Fig 1. Frequency distribution of egg by female bruchid beetle

PROJECT 03: MANAGEMENT OF POST HARVEST PROBLEMS IN GROUNDNUT

Sub-project 1: Physiology and biochemistry of seed viability and dormancy in Groundnut (P.C. Nautiyal and J. B. Misra)

A. SEED VIABILITY

A. 1. Pod drying and storage

Work conducted at NRCG showed that groundnut seed looses viability rapidly during storage. The problem of loss of viability is more serious in the groundnut produced in the rabi or summer seasons. High pod-temperatures and untimely rains during drying affect the seed quality and storability of the groundnut produced in the summer season. A simple, and economic drying method (NRCG-method) was developed to avoid the exposure of pods from direct sunlight and untimely rains, while drying in the field. The NRCG-method was compared with three drying methods viz., i) DOR (Directorate of Oilseeds Research) method, ii) windrow methopd, and iii) conventional-heap method (generally followed in various parts of India). NRCG-method showed its superiority in terms of retention of seed viability and seed quality, over other three drying methods, more specifically when pods experience rains while drying in the field. Trials were conducted in replicates during two summer seasons (1998, 1999) with cv. GG 2 (non-dormant). Immediately after uprooting the plant with pods attached were kept for drying by one of the methods described below.

A. 1.1. NRCG-method

In this method a tripod type structure (pyramid shape) was raised in the field with the help of three bamboo poles each about 1.5 m long. A coir rope was wound around the structure starting from the bottom to the top, while maintaining a space of 6-8 cm between two loops. Immediately after harvest groundnut plants were hanged on the rope of the structure in inverted position, pods up and haulm down, and the structure was filled with groundnut plants in a way that the pods of an upper ring covered the haulms of the lower ring. Thus forming a sloping structure like the roofing of a thatched house. The plants were arranged starting from the bottom ring to upwards. Groundnut pods along with the plants were allowed to dry in the structure in the field for five days.

A. 1.2. Conventional, farmers' method

Groundnut pods were dried following the conventional method followed in the Saurastra region of Gujarat and in some other parts of our country. In this method plants after digging were heaped in a circle, about 1.5 m in diameter and 0.75 m in height for five days.

A. 1.3. Windrow method

After digging, plants were left in rows, in the field for drying for five days.

A. 1.5. DOR-method

In the DOR-method (DOR, 1983) plants were tied in bundles and plant bundles of about 0.5 m in diameter. Then the bundles were kept for drying in pairs in such a way that one of the pair was placed in the field up-side down and the other on the top of the former right-side-up. This way the haulms of the upper bundle shaded the exposed pods of the inverted lower bundle from direct sunlight. Each evening the upper heap was removed and the pods in both the bundles were exposed. The heaps were returned to the inverted position the next morning. This practice was repeated for five days.

During 1998 crop was dried in two sets. The first was set up on 1st, June 1998 and four methods viz. windrows, conventional-heap, DOR, and NRCG methods were tried. A second set was arranged on 6th June 1998. In the second set pods were dried only following the NRCG and DOR methods, and the performance of these two methods in the situations when curing/drying encounters rains was compared. The second set experienced rains on the 4th and 5th days of drying in the field.

After drying for five days the pods were picked by hand, sun dried in thin layer to a moisture content between 5 and 6.5% in 1998 and 8.7 and 9.5% in 1999. Pods after drying in thin layers for two to three days were packed in 10 kg capacity polyethylene lined gunny bags and stored at ambient conditions.

Loss of moisture from the pods during drying and germinability

In both the years the pod moisture contents after five days of drying were in the following decreasing order, NRCG method >DOR method > conventional method >windrow method. Pod moisture at the time of harvest generally remains between 25-45%. Since, the temperatures and relative humidity in two drying seasons were distinct, the rate of loss of moisture from the pods in different drying methods in two summer seasons were also distinct.

In windrows seed germinability was affected immediately after drying (Table 1). Germination percentage (mean of two years) of the seeds obtained from the pods dried following windrows (15%) was lower than the seeds obtained from the pods dried following the DOR (53%) and the NRCG (70%) methods. Higher germination percentage in the DOR and the NRCG methods might be ascribed to the lesser pod temperatures during curing (around 38°C), as pods in these two drying methods were protected from direct sunlight. However, in the DOR method some peripheral pods remained exposed to sunlight resulting in 2 to 3°C higher temperatures than in the central pods. In NRCG method most of the pods were protected from direct exposure of sun light while drying.

B. Basic studies

B. 1. Instars of *Caryedon serratus* (Olivier)

The groundnut bruchid, *Caryedon serratus* Olivier (*Bruchidae: Coleoptera*) is the major storage pest of groundnut causing considerable damage to groundnut pods as well as seeds. Enough information is presently available on the biology, population dynamics, incidence levels, varietal resistance etc,. However, there are certain information missing in the literature such as details on the moulting behaviour leading to instars of grub. Studies were carried out to fill these gaps. Four grub instars taking a total of about 52 days were found in the insect. The last instar took 17 days but the first and third instars took 13 days each on an average (Table 7). The adult male lived for about 20 days while the female lived on an average for 16 days. The female laid eggs continuously for a maximum of 9 days with a mean of 6 days. Maximum number of eggs (64%) were laid during the first four days (Fig.1). The post-oviposition periods ranged from 2 to 20 days with a mean of 9 days. The male lived for 4 to 27 days with a mean of 20 days, while the female lived for 7 to 25 days with a mean of 16 days. The grub after moulting pushed the moulted skin back. The measurements of different instars are given in table 8. There was an increase in the size of the grub with increase in the instar. Adult female was bigger in size (6 mm length and 3 mm width) compared to the male (6 mm length and 3 mm width). The head capsules of the first and second instars were similar in size (0.3 mm), but third instar onwards the size gradually increased.

Table7. Post embryonic observations and the measurements on the bruchid beetle *C. serratus*

Stage	Number observed	Duration range (days)	Mean ± SD (days)
Egg	69	3 to 5	4.6 ± 0.7
Larval instar			
First	29	10 to 19	13 ± 2.3
Second	24	7 to 15	8.8 ± 1.7
Third	16	7 to 22	12.9 ± 5.2
Fourth	3	17	17 ± 0.0
Pupal period	19	6 to 22	12.2 ± 5.2
Female			
Pre-oviposition	10	10 to 4	1.8 ± 0.9
Oviposition	10	3 to 9	5.9 ± 2.0
Post-oviposition	10	2 to 7	8.6 ± 5.7
Longevity	10	7 to 25	16.3 ± 5.3
Male			
Longevity	10	4 to 27	19.6 ± 6.0

Table-12. Effect of crop combinations (intercropping) on disease development and yield of groundnut during kharif 1998-1999

Treatment	Kharif 1998					Kharif 1999				
	Disease Intensity(%)				Yield (kg/ha)	Disease Intensity(%)				Yield (kg/ha)
	ELS	LLS	Rust	Stem Rot(%)		ELS	LLS	Rust	Stem Rot(%)	
G'nut + Pigeonpea	25.93	35.08	26.40	6.98	740.74	34.33	25.43	45.59	3.04	592.59
G'nut + Pearlmillet	25.92	33.34	16.45	4.26	524.22	30.70	27.05	40.62	6.13	407.98
G'nut + Sorghum	23.34	29.66	19.79	3.51	259.80	36.05	25.57	33.70	7.75	454.70
G'nut +Cotton	30.31	36.62	22.15	2.36	717.95	30.79	23.95	39.21	5.68	529.91
G'nut. +Castor	30.97	37.02	27.14	6.03	717.95	25.43	23.95	44.14	5.25	524.22
Control (Sole G'nut)	29.61	38.66	28.76	12.03	888.89	33.06	25.43	47.47	6.28	787.46
C.D. (0.05%)	3.82**	N.S	3.03**	5.82*	224.11*	N.S	N.S.	N.S.	N.S.	49.25*

incidence was reduced by 56.59 % in the treatment of mustard cake. Yield levels were low during kharif 1999 due to dry spells during the critical period of crop growth (Table 11).

B. 3. Intercropping

During kharif 1998 groundnut + sorghum reduced ELS by 21.70% followed by Groundnut + Pearl millet and Groundnut + Pigeon Pea. As regards LLS though the results were non significant groundnut + sorghum and groundnut + pearl millet were found to be better in reducing the intensity of LLS. Groundnut + Pearl millet intercropping gave maximum reduction of rust (42.69 %) followed by groundnut + sorghum (31.81 %) and groundnut + cotton (22.98 %). Groundnut + cotton significantly reduced stem rot incidence by 80.38 % followed by groundnut + sorghum (73.06 %) and groundnut + pearl millet (64.58 %) During 1999, though the disease intensity of all the diseases did not differ significantly among the treatment, intercropping of groundnut + castor, groundnut + pearl millet and groundnut + cotton were relatively better in minimizing the intensity of ELS where as in case of LLS, intercropping of groundnut + cotton, groundnut + castor and groundnut + pigeon pea were better. However, groundnut + sorghum intercropping gave maximum control of rust (29%) followed by groundnut + cotton and groundnut + pearl millet. Yield levels were low due to the dry spells during the crop growth (Table 12).

B. 4. Crop Rotation

During summer 1999, upland paddy-groundnut-upland paddy crop rotation gave 63 % control of stem rot. However, during kharif 1999, groundnut - wheat-groundnut crop rotation realized 59 % control of stem rot which is commonly followed rotation in Gujarat and else where in the country. All the crop rotations tried had significantly reduced the control of ELS and LLS but these rotations had no significant effect on rust disease development.

B. 5. Effect of foliar application of biocontrol agents, biofungicides, and chemical fungicides on disease development and yield of groundnut

Two years data (kharif 1998-1999) revealed that foliar application of carbendazim 0.05% + mancozeb 0.2% significantly reduced the intensity of ELS by 34 %, LLS by 46 % and rust by 36% and gave an average yield of 1146 Kg/ha. Also, foliar application of aqueous extract of mustard cake (5%), culture filtrates of *Penicillium islandicum* and *Verticillium lecanii* were equally effective in controlling these foliar diseases. Foliar application of culture filtrate of *Verticillium lecanii* and foliar application of *T. harzianum* + soil application of *T. harzianum* gave 28 -33 % control of stem rot (Table 13)

Table 1. Effect of plant growth promoting rhizobacteria on nodulation, growth and yield of the groundnut cultivar JL 24 in pots in the post rainy and rainy seasons of 1999 (average of three replications)

Isolate	Nodule no. /plant		Plant biomass/plant (g)		Pod yield /plant (g)	
	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif
Control	89	83	14.82	11.91	4.17	3.25
PGPR 1	139	121	20.98	16.08	5.20	4.06
PGPR2	144	134	23.62	17.32	5.25	4.11
PGPR 3	106	92	18.00	13.25	4.53	3.82
PGPR4	151	129	19.75	15.83	5.10	3.99
PGPR 5	116	102	13.82	12.68	4.67	3.89
PGPR 6	93	78	15.93	14.75	4.38	3.25
PGPR 7	81	74	14.36	12.95	3.49	3.40
PGPR8	102	93	19.45	14.85	4.81	3.60
PGPR9	121	122	18.76	15.25	4.45	3.42
CD(0.05)	20.2	22.6	4.84	3.68	0.91	0.73

Table 2. Effect of PGPR on the growth, yield and nutrient uptake in the groundnut, cultivar GG 2, in the rainy season of 1999 under field conditions (mean of four replications)

Isolate	PY (kg/ha)	Plant biomass (g/plant)	NDW (mg/plant)
Control	1872	17.91	86.4
PGPR 1	2350	24.48	116.4
PGPR2	2320	27.28	103.0
PGPR3	2170	21.48	91.4
PGPR4	2315	24.48	103.4
PGPR5	2157	19.06	108.0
PGPR6	2175	20.94	104.2
PGPR7	2045	20.55	108.1
PGPR8	1955	18.48	105.2
PGPR9	1945	19.52	85.6
CD(0.05)	258	4.7	5.15

Table 3. Cyanogenic effect of rhizobacteria on growth and yield of the groundnut, cultivar JL 24, during the rabi-summer and kharif seasons of 1999 (average of three replications)

Isolate	Nodule number/ plant at 45 DAS		Root length/ plant (cm)		Biomass / plant (g)		Pod yield/ plant (g)	
	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif	Rabi	Kharif
Control	73	82	28.65	27.23	14.18	13.86	3.45	3.32
Cyanogenic: *Pseudomonas* spp. (C42)	51	49	20.05	18.28	10.83	10.15	2.42	2.20
Pseudomonas spp. (C103)	45	35	18.32	30.17	11.12	09.69	2.47	2.15
Pseudomonas spp. (C220)	92	101	26.37	25.89	12.92	12.87	3.21	3.05
Pseudomonas spp. C63	27	31	19.26	17.23	11.05	09.48	2.01	2.02
Pseudomonas spp. (C265)	86	90	25.36	27.83	12.13	11.37	3.66	3.53
Non-cyanogenic: *Pseudomonas* spp. C185	108	105	38.25	39.32	19.01	17.56	4.45	4.35
Beijerinckia spp. (363)	121	112	33.21	36.24	16.12	16.24	4.17	4.13
Beijerinckia spp. (359)	76	83	35.12	34.17	13.67	12.65	3.87	3.92
Beijerinckia spp. (39)	84	68	36.27	36.34	17.18	15.90	4.07	3.81
Pseudomonas spp. (387)	69	62	26.64	28.15	14.15	12.63	3.35	2.95
SE (±)	7.19	5.92	2.32	2.83	1.17	1.14	0.28	0.24

in the rainy season of 1999 (Table 2). Interestingly again, phosphorus and nitrogen contents of plants and the kernels were higher when inoculated with the PGPR cultures. P content was increased by 20-30% and N contents by 6-12%. Population densities of the three PGPR cultures viz., PGPR1, PGPR2 and PGPR4 on the roots, as determined by the intrinsic antibiotic resistance patterns, were log 6.1, log 5.8 and log 5.6 c.f.u/g of root at 21 DAS, respectively, in pots.

C. Deleterious Rhizobacteria (DRB)

Continuous cultivation of a particular crop on the same field is known to lead to the population build up of the cyanogenic microflora especially the rhizobacteria depending on the nature and amount of cyanogenic glucosides exuded from the plant roots. These rhizobacteria impairs the growth and yield of crops in many ways. When groundnut plants were inoculated with these cyanogenic microflora drastic reduction in yield was found in both the rabi and the kharif seasons. The cyanogenic isolate C42, C103 and C63, all fluorescent pseudomonads, inhibited plant growth and yield significantly (Table 3). Reduction in pod yield was as high as 29.85%, 41.74% and 28.40%, respectively, by C42, C103 and C63. In the kharif, 1999, the reduction was more. Nodulation was also found to be inhibited by C 103 and C 42. However, increase in yield and growth of groundnut in rabi/summer as well as in kharif season was observed by seed bacterisation with the non-cyanogenic isolates like, C185 (fluorescent *Pseudomonas*) and 397 (*Beijerinckia sp.*).

D. Phosphate Solubilizing Microorganisms (PSMs)

Pot and field trials were conducted for studying the effect of phosphate solubilizing microorganisms on the growth, yield and nutrient uptake of groundnut during 1999.

Seed bacterisation with only PSM1, a fungus, and PSM5, a bacterial isolate, resulted in significantly higher pod yield, root and shoot biomass, P-uptake than the control and other isolates (Table 4) in the pot experiment. Better performance of PSM was obtained with the application of SSP than rock phosphate.

Two bacterial isolates (PSM 1 and PSM 5) significantly increased pod yield, plant biomass, nodule dry weight and P uptake in the field also when compared to *Pseudomonas striata*.

E. Supply of biofertilizer to AICRP(G) centres and Agril. Universities

Two bradyrhizobial isolates (IRG6 and IRG40) and three PSM cultures (*Pseudomonas striata*, *Bacillus polymyxa* and *Bacillus circulans*) were supplied to different AICRP(Groundnut) centers, Agril. Universities, in the centers in the north-eastern states in collaboration with NRCG and to the Biovillage and IVLP programmes.

Table 1a. Effects of various organic matter in groundnut during the second consecutive season (Kharif 1998)

Treatments	Weed biomass (Kg/ha dry wt)	Yield (kg/ha) during 1998	
		Pod	Haulm
Control	317	830	3189
NPK (40: 40:40)	256	975	3950
FYM (10 t/ha)	469	1002	4325
Oilseed Cakes (1 t/ha)	486	927	3987
Cow dung Slurry from Biogas (10 t/ha)	390	907	3466
Briquette of Peanut shell and cotton Wasle (10 t/ha)	395	872	3261
Biofertilizers (PSM + *Bradyrhizobium*)	388	954	3510
Mulch with wild sorghum (20 t/ha)	377	890	3463
LSD (0.05)	70.4	81.6	378

Table 1b. Effects of various organic matter in groundnut during the third consecutive season (Kharif 1999)

Treatments	Pod yield		Shelling		100-seed mass	
	kg/ha	% incr.	%	% incr.	(g)	% incr.
Control	710		71.8		46.4	
Green manuring with Mungbean	840	18.3	72.5	0.9	49.5	6.7
Bio agents	872	22.9	73.6	2.5	47.7	2.7
Chemical (N P K)	1021	43.9	72.0	0.3	48.9	5.4
FYM	1196	68.5	73.0	1.7	50.9	9.7
Cake	1070	50.8	73.0	1.6	48.2	3.8
Biogas slurry	1044	47.1	74.2	3.3	47.2	1.7
Peanut/cotton Briquet	875	23.2	71.8	-0.1	47.9	3.2
Wild Sorghum	845	19.1	72.4	0.8	47.8	2.9

A. 3. Long term experiment on Nutrient dynamics

Meager information is available on cumulative as well as residual fertility build up in the long run for whole cropping systems. A long term experiment with five popular groundnut based cropping systems viz: monocropping of groundnut, two intercropping systems (with pearl millet and pigeon pea) and two sequential cropping systems (groundnut-wheat and groundnut-wheat-green gram) was initiated during kharif 1998 under different combinations of organic and inorganic fertilizer regimes. Application of organic manure did not improve the yield of kharif groundnut. However, there was a significant response of residual effect of FYM in pigeon pea and pearl millet (as intercrops) and the following wheat crop. Yields under FYM applied treatments of wheat increased by 10-11 % and of pigeon pea by 14.5- 19 % over 100 % inorganic fertilizer applied to the respective crop. Nutrient analysis of the soil indicated considerable variation in the available nitrogen (more in groundnut+ pigeonpea and groundnut-wheat-green gram and least in mono cropped groundnut). Not much variation in organic carbon content of soil after harvest of kharif groundnut and rabi wheat was observed after two years of experimentation (Table 3).

Soil pH from the rhizosphere (0-15cm) was measured after harvest of kharif groundnut. The slight increase in soil pH (0.04-0.58) over control sole groundnut with 200 and 300 % cropping intensity (intercropping of pearlmillet and pigeonpea with groundnut, sequential cropping of groundnut- wheat, and groundnut-wheat-greengram) may be explained to depletion of acidic minerals from top15 cm of soil layer. In general, FYM application tended to reduce pH irrespective of the cropping intensity (0.02 to 0.15) over no FYM.

A. 4. Moisture extraction pattern in intercropping system

A pilot experiment on two intercropping systems using rain-out shelter was laid out during kharif 1999. Two treatments namely; no soil moisture stress (1.0 IW/CPE) and soil moisture stress (0.5 IW/CPE) were imposed. Soil samples from 0-15 and 15-30 cm soil depth at 15 days intervals starting 25 days after sowing (DAS) were drawn for soil moisture determination. In groundnut + pearl millet intercropping, moisture stress was more in 0-15 cm soil depth where as in groundnut + pigeonpea intercropping, initially moisture stress was observed in 0-15 cm soil depth but after 40 DAS, moisture stress up to 30 cm soil depth was observed. Observations on root dry weight and root length at 30 and 45 DAS also indicated more competition for water and radiation in pigeonpea than in pearl millet intercropping systems.

A. 5. Evaluation of Soil Conditioner "Terra-Care" in summer groundnut (under contract service)

A field experiment was conducted to evaluate soil conditioner "Terra Care" a coconut industrial by-product, during summer 1999. Four doses of "Terra Care" namely,

B. SEED DORMANCY

B. 1. Response of dormant and non-dormant Spanish groundnut to ABA and ethrel during seed development

To understand the basic nature of fresh seed dormancy the germination of seeds with (GST) and without (GSW) testa of dormant and non-dormant cultivars when treated with ethrel or ABA at different seed development stages were studied. Seeds of non-dormant type were responsive to ethrel at early stage of seed development, whereas the dormant type responded at maturity. The regulation of fresh seed dormancy appeared to be more under control of testa than the cotyledons. Almost similar patterns of accumulation of fresh weight and dry weight in the seeds of dormant and non-dormant cultivars were found, though the germination behavior after two months of storage of the seeds of different development stages showed different pattern.

B. 2. *In situ* sprouting and pod losses in Spanish groundnut

Experiments were conducted to evaluate pod losses due to in situ sprouting of seeds and to study the nature of fresh seed dormancy in Spanish groundnut cultivars and germplasm accessions. It is well known that most of the early maturing Spanish groundnut cultivars do not have fresh seed dormancy and are virtually non-dormant. These cultivar also showed variation in the degree of fresh seed dormancy. For this reason we calculated a fresh seed dormancy index (DI) which is a ratio of the germination percentage obtained after treating freshly harvested seeds with ethrel (dormancy breaking agent) with that obtained in the non treated fresh seeds. Large genotypic variations in pod losses in the field, and fresh seed dormancy index (DI) were found. Almost all cultivars exhibited fresh seed dormancy to some degree, though the values of DI varied from 2 % in cv. Chico to 88 % in ICGS 44 (dormant check). Cultivars with less than 10% DI showed more pod losses (14-20%) as found in cvs. Chico (20%), TAG 24 (15 %), GG 2 (14%) and Girnar 1 (17%). The cultivars like Jyoti, VRI 3 and CO 2 with higher DI (between 20 and 43%) showed least pod losses (4-5%). Cultivar SB XI a typical Spanish type did not show any *in situ* sprouting, hence no pod losses due to in situ germination. Some germplasm accessions in the Spanish group were identified to possess high degree of fresh-seed dormancy (DI range: 50% to 96%). Among 40 germplasm accessions studied, direct relationship was found between fresh seed germination percentage in the laboratory and plants having percent sprouted seeds ($r=0.86$) in the field at harvest.

PROJECT 05: STUDIES ON GROUNDNUT BASED CROPPING SYSTEMS FOR RAIN DEPENDENT AREAS

(Devi Dayal, P.K.Ghosh and Y. V. Singh)

A. Cropping systems

A. 1. Effect of groundnut genotypes in intercropping systems:

Performance of 25 groundnut genotypes (9 Virginia and 16 Spanish) was evaluated during the kharif season of 1999 in two intercropping systems viz: groundnut-pearl millet and groundnut-pigeon pea. For Virginia types, 1 (groundnut) : 1 (intercrop) and for Spanish 3(groundnut): 1(intercrop) row ratios were followed. Sole crop of each genotype was also maintained as a control. Reduction in pod yield was more with pigeonpea ((up to 78%) than with pearl millet (up to 50%). In general, Virginia cultivars showed more reduction in dry matter production than Spanish cultivars. There were large genotypic differences for reduction in pod yield due to intercropping systems. Genotypes, GG20, M335 and M 13 among Virginia and J11, GG4 and GG2 among spanish types showed less reduction in pod yield due to intercropping system.

Observations on soil pH of rhizosphere (0-15cm) in groundnut cultivars indicated that rhizosphere pH slightly increased when groundnut was grown as an intercrop as compared to sole crop. Intercropping of groundnut with pigeon pea had higher values of soil pH than with pearl millet intercropping (Fig 1).

A. 2. Response to nutrients in the intercropping systems

Very little information is available on nutrient dynamics and requirement of cropping system as observed to individual components of respective systems. these aspects in component based intercropping system. Hence, field experiment was conducted with two intercropping systems viz: groundnut+pigeonpea (cv.BDN 2) and groundnut+pearlmillet (cv.M H 169) under different combinations of fertilizers. GG2, a *Spanish* cultivar of groundnut was grown in intercropping system. Three levels of fertilizer namely were evaluated in both groundnut and intercrops. In groundnut+ pearl millet, a significant linear response to the applied fertilizers for dry matter production and grain yield was observed in pearl millet. However, in case of pigeonpea, no consistence response was observed. Yield reduction in groundnut (40-50%) due to association of pearl millet under high fertility regimes was evident. Data on Land Equivalent Ratio (LER) showed that pearlmillet was a dominant competitor compared to pigeonpea as an intercrop with groundnut. Even at the lowest fertility level, LER of groundnut was reduced to 0.57 where as with pigeonpea at the same fertility level, the LER was 0.83 (Table 1).

PROJECT 04: INTEGRATED NUTRIENT MANAGEMENT IN GROUNDNUT

Sub-project 1: Development of biofertilizer packages for groundnut

(K. K. Pal and Rinku Dey)

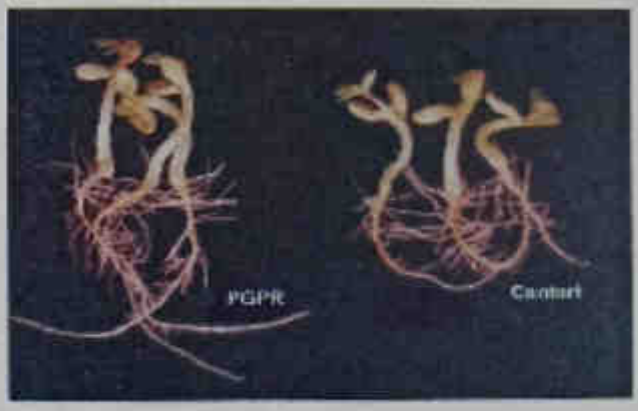
A. Biological Nitrogen Fixation

Bradyrhizobium: Two isolates, AS6 and AS9, out of eighty isolated from rice fallows were found to be very efficient in nodulation on the basis of number of active nodule produced and nodule dry mass. One of the isolates AS9 was molecularly tagged with Tn5::*lacZ* for studying the survival mechanism of bradyrhizobia under inundated conditions.

Host: For selection of groundnut with high BNF, two cultivars reported to have high BNF potential viz., JL24 and ALR2, were screened for studying intra-cultivar variation with respect to number of effective nodules. Three plants were selected from cultivars AK12-24 and six from ALR2 which had more than 100 effective nodules for further studies.

B. Plant growth promoting rhizobacteria (PGPR)

In continuation of the experiments conducted in 1998, experiments were also conducted in rabi-summer as well as in kharif season of 1999 to evaluate the performance of the PGPR cultures in pots and field. Nine cultures were selected, on the basis of germinating seed bioassay (plate 1). All the nine cultures belonged to the genus *Pseudomonas*. Three of these cultures; PGPR 1, PGPR 2 and PGPR 4 (all fluorescent pseudomonads)



Plat 1. Germinating seed bioassay of PGPR

were the best in producing siderophore (5 mm, 7.6 mm and 12 mm of orange halos in CAS agar plates after 72 hrs of growth), IAA (3.6, 7.8 and 9.3 mg/L) and solubilizing inorganic phosphate (48.52, 16.6 and 60 mg/100 ml broth, respectively). Interestingly, they were also found to be inhibitory *in vitro* to *Aspergillus flavus*, the aflatoxin producing fungus (produced 10-14 mm diameter of inhibition zones in King's B medium after three days of incubation). Inoculation these cultures (PGPR1, PGPR 2 and PGPR 4) increased the pod yield by 22-25%, the number of effective nodules at 45 DAS, and plant biomass in pot trials in the rabi-summer season (Table 1). Similar observations were also obtained in the kharif season. In a field trial also, similar benefits were observed

Table 4. Effect of PSM on the growth, and yield of groundnut (cultivar JL 24, kharif, 1999). In pots (results of one bacterial and one fungal culture only)

Treatment	Pod yield (g/plant)	Nodule dry wt. (mg/plant)	Shoot dry wt. (g/plant)
Control	3.95	73.45	13.18
RP20	4.46	78.34	15.28
RP40	4.63	93.87	14.98
SSP20	5.41	68.45	16.05
SSP40	5.24	84.34	17.24
RP20+PSM5	6.35	109.12	20.12
RP40+PSM5	6.78	118.24	18.13
SSP20+PSM5	6.56	87.34	22.45
SSP40+PSM5	7.21	112.6	20.18
RP20+PSM1	5.50	91.50	17.23
RP40+PSM1	6.12	72.00	18.67
SSP20+PSM1	5.96	81.24	20.34
SSP40+PSM1	6.78	98.29	18.45

PSM 5= Fluorescent Pseudomonas
PSM1 = Fusarium

Sub-project 2: Stndies on mineral nutrition and disordrs in groundnut

(A.L. Singh, Y.C. Joshi, R.K. Mathur)

A. Calcium and K nutrition of large seeded groundnut

Sand culture experiment was conducted in Kharif 1999, under various levels of Ca (50, 200 and 400 ppm) and K (50 and 100 ppm) to find out their role in the nutrition of large seeded groundnuts. Two large-seeded groundnut genotypes BAU 13 and JSP 19 (having 90 and 70 g/100 seed mass, respectively) and a small seeded genotype NRCG 6919 (35g/100-seed mass) were used in this study. It was observed that the large-seeded groundnut genotypes had higher requirement of Ca than the small seeded one and their seeds showed lower pod filling and were deficient in Ca. Increasing the Ca level to 200 ppm increased the concentration of Ca in seed and pod yield. The nutrient analysis of previous year experiments showed that increasing the level of Ca or K alone in the nutrient solution was not beneficial because these elements are antgonistic resulting in the lowering the concentration of the other element. The best dose for high yield was 100 ppm K + 200 ppm Ca for large-seeded groundnut and 100 ppm K +50 ppm Ca for small-seeded groundnuts

B. Screening for Calcium-efficient genotypes

Soil culture pot and field experiments were conducted to identyfy Ca-efficient groundnut genotypes. Eighteen groundnut genotypes were grown in pot and 30 in field under two levels of Ca (0, and 100 kg Ca/ha) and observations on plant growth and yield were recorded. Based on the relative performance of dry matter accumulation and pod yield, the groundnut genotypes NRCG 7085-1 & 6919, MOR 161, and ICGHNG 88448, were identified as Ca-efficient and TG 26, BAU 13, NRCG 7472 and 162 as Ca-inefficient.

C. Screening for P-efficient genotypes

Pot (soil culture) and field experiments were conducted to identify P-efficient groundnut genotypes for calcareous soil. Seventy genotypes were grown in field and 18 in pots under two levels of P (0 and 50 kg P/ha) and observations on plant growth and yield were recorded. Based on the relative performance of growth, dry matter accumulation and yields, the genotypes NRCG 7085-1, 1308, PBS 13, PBS,11037, 20016, 20057 and MOR 139 were identified as P-efficient and VRI3, SG 84-1, B 95 as P-inefficient. The plant samples of these experiments are being analysed for including P concentration and uptake also as one of the selection criteria in indentifying P-efficient genotypes and also studying uptake of other macro- and micro-nutrients.

D. Experimentation on the concepts of organic farming in groundnut

Various sources of organic matter such as FYM, slurry of cow/domestic animals, briquette from peanut-cotton waste, oilseeds cakes, mulching with local plant/weed material and Bio-fertilizers (PSM + *Bradyrhizobium*) were evaluated with an objective to meet the nutrient requirement of the crop and control of insects pests and diseases to produce pesticide free groundnut. During first year of experimentation, in general, poor yield was observed due to late planting of the crop. But during second and subsequent seasons clear-cut responses of these organics were observed on pod yield and other yield attributes. Though use of FYM, cow dung slurry, oilseed cakes, biofertilizers and mulching with local weed were promising organic farming approaches, the FYM, oilseed cakes, cow dung slurry and waste of peanut/cotton increased the weed biomass. During the third season of cropping (wet 1999), the FYM, oilseed cakes and cow dung slurry could increase the pod yield by 68.5, 50.7, and 47.1 % over control, respectively. However, green manuring, biofertilizers, waste of peanut/cotton and mulching with local plant material were almost at par and increased 18.3, 22.9, 23.2 and 19.1% yield over control, respectively (Table 1 a, 1 b).

B. LOW TEMPERATURE STRESS

Screening germplasm accessions:

About 300 germplasm lines were screened for cold tolerance during germination at a temperature cycle of 12°C/18°C (18/6 hours). The germination percentage varied from 60 to 100%, and root length from 0.46 to 2.50 cm. The seedling vigour index ranged from 35 to 252 only , and ten genotypes showed SVI more than 200.

PROJECT 06: STUDIES FOR TRADITIONAL RABI/SUMMMER AND IRRIGATED SITUATIONS

Sub-Project: Physiological studies on water, temperature, and salt stress

(Y.C. Joshi and P.C. Nautiyal)

A. HIGH TEMPERATURE STRESS

Leaf membrane thermostability

Groundnut productivity in rabi/summer season is seriously affected by the high temperature injury during pod filling phase especially in the semi-arid (SAT) regions. A protocol for the measurement of the leaf membrane thermostability as an indicator for high temperature tolerance, developed during the previous year was used for the study. The objective of the study was to estimate genetic variability for plant acclimating to high temperature stress and a combination of high temperature and water-deficit stress. Eight genotypes were used for this study. Leaf membrane thermostability in this experiment appeared to be related to the acclimation of the plants in high temperature. Leaves of the same age when collected at the reproductive stage (60 d after sowing), which experienced high temperature (maximum range 38-42°C) during March to May showed higher thermostability in some of the genotypes as measured by relative injury (RI) than the leaves of the same age collected from the canopy in the month of February, when the ambient temperature was low (max temp rasnged from 30-35°C). When the plants experienced high temperature and soil-moisture deficit stress the thermostability further increased (RI range: 34 to 67%). Thus it appeared that thermostability is a function of degree of acclimation to both high temperature and moisture stress (Table 1).

Table 1. Genotype variations in leaf membrane thermostability acclimitisation due to high temperature and soil moisture stress.

Genotype	Relative injury index (RI %)		
	Veg. stage	HT	HT + WS
ICG 44	48.3	44.8	45.2
TG 26	76.4	67.2	50.7
GG 2	78.9	59.3	53.3
ICGV 86031	71.4	66.5	51.2
TG 3	78.7	77.5	47.3
CSMG 84-1	60.3	56.0	30.1
ICGS 76	57.0	49.8	34.0
TAG 24	77.3	71.9	58.6

HT = High ambient temperature (range 38-42°C)
WS = water-deficit-stress

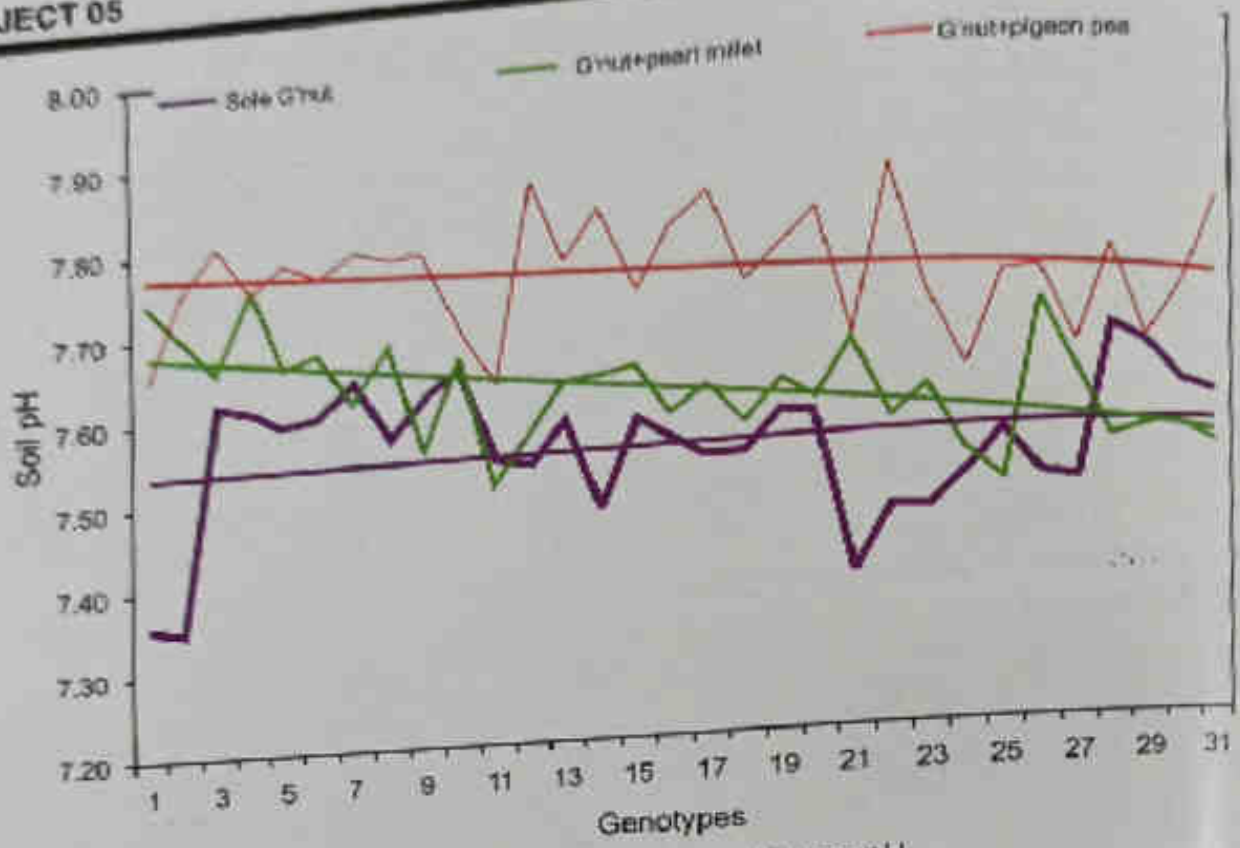


Fig 1. Effect of cropping system on pH

DEVELOPMENT OF SUITABLE SUITABLE AGRONOMIC PRACTICES IN GROUNDNUT (Up to June, 1999) (Devi Dayal and P.K.Ghosh)

A. Intercropping

Rabi-summer groundnut with short duration vegetables

Intercropping of short duration vegetables during the initial slow growth of summer groundnut can increase resource use efficiency of the cropping system. Intercropping of four vegetables, viz: coriander, spinach, fenugreek and radish grown in the space between two rows of summer groundnut were tested for two consecutive years. Pod yield was the highest (2820kg/ha) when fenugreek was intercropped. Substantial reduction in pod and straw yields, shelling percent, 100 pod mass and 100-seed mass was observed when spinach and radish were grown with groundnut. The lowest pod yield was recorded when spinach was intercropped. Fresh vegetable yield was the highest in radish followed by spinach. But the highest net return and benefit cost ratio (4.60) were recorded in intercropping with radish. Though fresh dry matter was greater in radish, groundnut was affected more by spinach. This may be attributed to the fact that leaf arrangement of radish is such that even in a dense population of radish, shading was less than that caused by spinach.

B. Mulching

Mulch affects the hydrothermal regimes of the soil. Low temperature during germination and initial growth and high temperature during pod development stages of summer groundnut are not conducive for high productivity. Therefore, suitability of two organic mulches namely: wheat straw and paddy straw (5t/ha), were tested along with polythene mulches of different gauges (50 and 10 microns) and colours (black and transparent). Polythene mulch was used either as strip between two rows of groundnut or as a sheet with perforated holes in which the seed were dibbled. The beneficial effect of polythene mulch was more in earlier stages by providing early germination (2-4 days) and flowering (6 days) compared with organic mulches and the control. Polythene mulches caused higher (18.55) dry matter production / plant recorded at harvest compared with the control (16.87). Contrary to the greater biomass, maximum pod yield was given by organic mulch, which was 20.8 % higher than the control. White polythene (10 micron) and black polythene (50 micron) increased pod yield by 15 % over the control. The mean increase in pod yield due to polythene mulch was 13 % over control. Polythene with hole was slightly superior to strip application. When wheat straw was combined with black polythene (50 micron), yield increase of 26 % over the control was recorded. The higher pod yield in organic mulches than polythene mulch was mainly due to heavier pod and kernel in this treatment.

0, 700, 1400 and 2100 kg/ha applied as basal dressing along with three levels of irrigation (1.0, 0.8, and 0.6 IW/CPE) and two levels of fertility regimes (25-50 and 12.5-25; N and P2O5 kg/ha) were tested in a split plot design with three replications. "Terra Care" and the fertility regimes did not influence growth and yield attributing parameters of groundnut significantly. Similarly, pod and haulm yields and water use efficiency (WUE) were not affected significantly by "Terra care". Irrigating summer groundnut at 1.0 IW/CPE gave the maximum pod yield of 2056 kg /ha. Imposing even mild moisture stress (0.8 IW/CPE) significantly reduced the pod yield. However, haulm yield reduced significantly when moisture stress of 0.6 IW/CPE was imposed. The WUE increased consistently as moisture stress increased from 1.0 to 0.6 IW/CPE but the differences were not significant (Table 2).

B. Evaluation of herbicide " Napropamide" in groundnut based cropping system

A new pre-emergence herbicide " Napropamide" (Amide group) was evaluated in kharif groundnut based cropping system. Two Rabi crops namely, wheat and gram and two summer crops (pearl millet and green gram) were grown to assess the residual effect of the herbicide. Effects of herbicide (Napropamide) in controlling weeds (monocots/ dicots) were similar to Pendimethalin (recommended herbicide). However, there was a considerable residual effect on germination, growth and yield of succeeding wheat crop under Napropamide treatment. No residual effect on gram on germination, growth and yield was, how ever observed.

Table 1. Land Equivalent Ratio (LER) under different fertility levels in groundnut based intercropping system

Fertility levels		Groundnut + Pigeon pea(3:1)			Groundnut + Pearl millet(1:1)		
Groundnut	Intercrop	Groundnut	Pigeon pea	Total	Groundnut	Pearl millet	Total
F1	F1	0.83	0.87	0.86	0.83	0.92	0.85
	F2	0.87	0.67	1.54	0.59	0.46	1.05
	F3	0.86	0.67	1.53	0.47	0.55	1.02
F2	F1	0.83	0.67	1.50	0.57	0.30	0.87
	F2	0.92	0.77	1.67	0.51	0.55	1.06
	F3	0.85	0.74	1.59	0.47	0.65	1.12
F3	F1	082	0.70	1.52	0.45	0.44	0.89
	F2	0.83	0.77	1.60	0.54	0.51	1.05
	F3	0.87	0.71	1.58	0.35	0.52	0.87

F1; 50% recommended doses of fertilizers (RDF) F2; 100% RDF F3; 150% RDF

Table 2. Effect of "Terra care" irrigation and levels of fertilizers on yield and water use efficiency (WUE) of summer groundnut

Treatment	Pods/pl	Pod wt./pl	Pod yield	Haulm yield	Harvest index	WUE
		(g)	(kg/ha)	(kg/ha)	(%)	(kg/mm/ha)
Doses of "Terra Care"(kg/ha)						
0	10.11	6.96	1887	4452	29.77	4.06
700	9.22	6.80	1873	4310	30.29	4.03
1400	10.39	7.51	1907	4406	30.23	4.13
2100	9.11	6.94	1810	4313	29.56	3.92
C. D. (0.05)	NS	NS	NS	NS	NS	NS
Levels of irrigation (IW/CPE)						
1.0	10.74	8.0	2056	4511	31.30	3.73
0.8	9.79	7.37	1836	4557	28.72	4.08
0.6	8.58	5.77	1716	3963	30.21	4.29
C. D. (0.05)	1.02	0.76	215	422	NS	NS
Doses of fertilizers (kg/ha)						
25-50-0	9.92	7.15	1878	4443	29.71	4.15
12.5-25-0	9.50	6.95	1860	4244	30.47	3.92
C. D. (0.05)	NS	NS	NS	NS	NS	0.208

Table 3. Organic carbon (O. C.) and available nitrogen (0-15cm) in different groundnut based cropping systems.

Cropping system	O.C. (%)	NH4 N (kg/ha)	NO3 N (kg/ha)	Total N (kg/ha)
Sole groundnut	0.38	87.42	32.53	119.96
Groundnut+pearlmillet (1:1 intercrop)	0.38	87.47	34.80	122.27
Groundnut+ pigeonpea (3:1 intercrop)	0.40	94.11	35.77	129.88
Groundnut-wheat	0.38	89.45	35.92	124.93
Groundnut-wheat-greengram	0.39	96.05	38.21	134.24

B. Basic studies on Al-toxicity at NRCG

Thirty one groundnut genotypes were screened for their tolerance of Al-toxicity at 500 µM Al (a toxic dose for many crop species) in sand culture pot experiment and the groundnut genotypes, FeESG 8, PBS 13, NRCG 7599 and 1038 were found comparatively more tolerant of Al-toxicity than other genotypes.

In another experiment on the standardization of Al doses for its toxicity in groundnut, it was observed that 200 mM of Al was not detrimental to and some of the groundnut genotypes showed better growth. This 600-1000 mM of Al (Table 5) was detrimental to the growth.

Table 5. Standardization of Al doses for groundnut in pot studies during kharif 1999

Treatment Pod yield (g/pot)

Treatment	Pod yield (g/pot)					
	NRCG 7599		TAG 24		NRCG 6919	
	Mean	% dev.	Mean	% dev.	Mean	% dev.
0 ul	13.7		8.3		17.7	
200 ul	16.8	23.0	8.1	-2.0	17.8	0.9
400 ul	13.9	1.5	8.0	-3.6	16.9	-4.1
600 ul	13.5	-1.1	7.1	-14.5	16.9	-4.1
800 ul	13.0	-4.9	5.6	-32.1	16.9	-4.5
1000 ul	12.5	-9.0	6.5	-21.5	13.7	-22.4
1500 ul	10.7	-21.6	4.9	-41.2	13.3	-24.9
2000 ul	9.2	-32.7	4.0	-52.5	10.8	-35.8
Mean	**12.9**		**6.6**		**15.5**	

C. Isolation and testing of soil microbes responsible for P release and high nitrogen fixing *Bradyrhizobium* in acid soils

Eight isolates of PSM from the acidic soils of Tura and Manipur and twenty isolates of *Bradyrhizobium* from nodules and rhizospheric acid soils of Tura, Manipur and Barapani are being cultured and purified for their further testing in Acid soils of NEH.

A simple method for screening groundnut for their tolerance of Al-toxicity was developed employing seedling bioassay technique based on the principle that the root growth of germinating seedlings of resistant genotypes will tolerate much higher concentration of Al. Root growth of germinating seedlings, grown under various concentrations of Al (as AlCl3,6H2O) for seven days at pH 4.5, were measured. Also root were stained with hematoxylin and eriochrome cyanine R. The cultivars which were not stained with either of the stains at any Al level and did not show more than 40% reduction in root growth at the 400 uM of Al were ranked as tolerant whereas those which stained showed

Table 1. Distribution for qualitative traits among 501 Germplasm accessions

Traits	No.of accessions			
Growth habit	Decumbent 1	Decumbent 2	Decumbent 3	Erect
	0	0	76	425
Branching pattern	Alternate	Sequential main stem	Irregular, without flowers on	Irregular, with flowers on main stem
	1	447	51	2
Stem hairiness	Sub glabrous	Moderately hairy	Very hairy	Woolly
	293	193	15	
Stem Pigment	Absent		Present	
	402		99	
Leaf colour	Light green	green	Dark green	
	8	484	9	
Leaf hairiness	Almost glabrous	Hairy below	Hairy below with bristle	Very hairy
	262	222	17	0
Leaf shape	Lanceolate		Oblong	
	3		498	
Leaf tip	Acute		Obtuse	
	3		498	
Inflorescence	Simple		Multiple	
	385		116	
Flower colour	Orange	Dark Orange	Garnet	
	1	498	2	
Peg pigmentation	Present		Absent	
	437		64	
Pod size	Small	Medium	Large	
	12	483	5	
Pod beak	None	Sight	Moderate	Prominent	Very Prominent
	96	361	40	3	0
Pod constriction	None	Slight	Moderate	Prominent	Very Prominent
	0	294	158	40	7
Pod reticulation	Smooth	Sight	Moderate	Prominent	Very Prominent
	2	420	68	11	0
Testa Colour	Rose	Salmon	Light red	Red	Light purple	Purple
	29	442	1	24	1	2

PROJECT 07: DEVELOPMENT OF SUSTAINABLE PRODUCTION TECHNOLOGIES FOR PROMOTION OF GROUNDNUT CULTIVATION IN NON-TRADITIONAL AREAS OF EASTERN AND NORTH-EASTERN INDIA.

(A. L. Singh, M.Y. Samdur, K. K. Pal, Jai Singh, N.P. Singh, D. P Patel, G.C. Munda, Kailash kumar, Mousami Raychoudhuri, B. K. Sharma, Sukumar Ray, M. Datta and S. Mitra)

A. Experimentation's in North-Eastern Hills

To provide suitable cultivation technology through understanding scientifically the problems of groundnut cultivation in North-East Hills, three collaborative experiments were conducted at various ICAR Research complex at Barapani (Meghalaya), Lembucherra (Tripura), Imphal (Manipur) and Tura (Meghalaya).

A. 1. Evaluation of recently released cultivars for their introduction in NEH region

The recently released groundnut cultivars were grown along with the suitable check (JL 24) for that region under the standard package of practices and evaluated for their pod yield, and tolerance of Al- and Fe-toxicities and Ca and P deficiencies, early and late leaf spot diseases and insects pests.

The data of the experiment at various locations have shown that pod yield of recently released groundnut cultivars ranged from 183-3520 kg/ha depending upon the location, year and severity of acidity (pH 4.5- 5.9) and Al-toxicity. The range of pod yield and average yields were 1212-2070 and 1699 kg/ha respectively at Manipur, 558-2225 and 1184 kg/ha at Barapani and 780-1300 and 958 kg/ha at Tura, during 1998. During 1999 due to lesser viability of seed and severe Al-toxicity there was poor germination in most of the groundnut cultivars except ICGS 76, at Barapani and hence some cultivars performed very poorly. The experiment at Tura showed poor germination due to poor viability of seeds. The range of pod yield and average yields were 183-2100 and 1184 kg/ha, respectively during 1999 at Barapani. Among the groundnut cultivars ICG 76 and ICGV 86590, ICGS 11, ICGS 44 , Girnar 1 and TKG 19A showed their comparatively more tolerance to soil acidity and Al-toxicity and showed high yield and VRI 3, TG 22, And DRG 12 were sensitive and low yielder. ICG 76 and ICGV 86590 were found to be most suitable for soil with high Al-toxicity.

A. 2. Screening and evaluation of germplasm lines

About 100 germplasm lines were grown under low pH condition (pH 4.5-5.9) under fertilized (50 kg/ha P + 2500 kg/ha lime) and unfertilized (control) conditions and the performance of these genotypes were assessed for pod yield and their tolerance of Al and Fe toxicities and Al-induced Ca- and P-deficiencies.

PROJECT 08: GERMPLASM MANAGEENT OF CULTIVATED GROUNDNUT (*A. HYPOGAEA* L.) AND IT'SWILD RELATIVES.

Subproject 1: Collection, evaluation, documentation and distribution of cultivated groundnut and related *Arachis* species (K. Rajgopal, K. Chandrun, S.K. Bera, V. Nandagopal and S. Desai)

A. Acquisition of germplasm

Three hundred ninety-four accessions of cultivated groundnut and forty-two accessions of wild *Arachis* species have been procured further from ICRISAT, Patancheru. Further six released groundnut cultivars were acquired from the originating Centres for detailed characterization.

B. Supply of germplasm

Three hundred ninety-nine accessions were supplied.

C. Characterization of germplasm

Five hundred and one germplasm lines belong to the ssp. *fastigiata* var.vulgaris were characterized for 19 qualitative and 27 quantitative traits. The distributions of the accessions for various qualitative traits are given in Table 1. NRCGs 10273, 10334, 10443, and 11429 showed > 70% shelling out-turn and > 50 g 100-seed mass.

A working collection (1939) comprising Spanish (1272), Valencia (416), Virginia bunch (126), Virginia runner (104), water use efficient lines (21), 145 released and pre-released cultivars and 250 promising lines were multiplied and evaluated at outreach centre, Bhubaneswar. A duplicate set of 42 accessions of wild *Arachis* species were also maintained at Bhubaneswar.

In an evaluation trial consist of Virginia bunch (126) and Virginia runner (104) accessions conducted at Bhubaneswar during rabi season thirteen Virgina runner accessions (ICG's 697, 2698, 4430, 4515, 4957, 4211, 4495, 6794, 2288, 4442, 5290, 6098 and 6784) and six Virginia bunch accessions (ICG's 863, 916, 920, 921, 1019 and 2659) were identified promising.

D. Screeining of germplasm against defoliators

Five hundred germplasm lines were grown under unprotected condition with GG 2 as control and scored for the foliar damage caused by the defoliators. The control showed 8-10% foliar damage. Thirty-three accessions were showed less than 5% damage and another 25 accessions showed good yield (>115g/m2) = 25) despite of more than 8% foliar damage.

more than 60% reduction in root growth were ranked as sensitive. In erichrome cyanine R staining, pink colouration and in hematoxylin staining, greyish-brown colouration along the entire root were the indicators of the Al sensitivity. This method is being further tested for a number of genotypes.

Table 1. Effect of *Bradyrhizobium* and PSM on the pod yield of groundnut (Cultivar ICGS 76) at Barapani during Kharif 1999

S.No	Treatment	Pod yield			
		1999		1999	
		kg/ha	% increase	kg/ha	% increase
1	Control	1530		1400	
2	FYM (10 t/ha)	2800	82.4	2150	53.6
3	N&K (20:40 kg/ha)	1680	9.8	1825	30.4
4	NPK (20:60:40 kg/ha)	2310	51.0	2050	46.4
5	T4+ *B. circulance*	1980	29.4	1930	37.9
6	T4+ IGR 40	1800	17.6	2250	60.7
7	T4+ *Pstrata*	1680	9.8	2180	55.7
8	T4+ *B. polymyxa*	1500	-	2200	57.1
9	T4+ TAL-1000	2430	58.8		
10	T4+ IGR-6	2170	41.8		
11	T4+ NC 92	2700	76.5		
	Mean	**2053**			

Table2. Effect of *Bradyrhizobium* and PSM on the pod yield of groundnut (Cultivar ICGS 76) at Manipur during Kharif 1999

S.No.	Treatment	Pod yield (kg/ha			% increase	In yield
		Lo (No lime)	L2 (2 t/ha lime)	Mean	Over Control	In L2 Over L0
1	Control (without P, K and biofertilizers)	880	1220	1050	-	(47.0)
2	*Bradyrhizobium*	950	1230	1111	5.8	29.5
3	PSM	1040	1370	1200	14.3	31.7
4	K50 (50 kg K_2O/ha)	1040	1310	1170	11.4	26.0
5	P50 (50 kg P_2O_5/ha)	1010	1340	1170	11.4	32.7
6	P50+ *Bradyrhizobium*	1190	1450	1320	25.7	21.8
7	P50+ PSM	1260	1440	1350	28.6	14.3
8	P50+ K50	1210	1580	1390	32.4	30.6
	Mean	**1070**	**1370 (28.0)***	**1220**		
	LSD (0.05)					
	Lime	31.3				
	Fertilizer	121				
	Interactions (LxF)	NS				

*Overall percent increase of yield in L2 over Lo

Based on the relative root and shoot growth and pod yield, the genotypes ICG, 1045, 3606 showed better tolerance to Al toxicity in acid soils at most of the locations. Application of lime increased the concentration of K in leaves but not the micronutrients. During 1998 and 1999 a trip was made to NEH Regions to visit the ongoing experiments and discuss the strategies for next kharif and Rabi, rabi-summer groundnut. There is an urgent need to grow groundnut, between Kharif and Rabi rice crop (Oct.-Jan.) using short duration cultivars for utilizing the residual moisture and fertility. Jorhat was identified as a hot spot for acidity and Al-toxicity. All the germplasm lines need to be tested for tolerance to Al-toxicity, cold, diseases resistance and P- and Ca-deficiencies by sowing them during November and January. The experiments need to be conducted in collaboration with AAU.

A. 3. Integrated nutrient management in groundnut

To compare the effects of inorganic nutrients (P, K), lime and biofertilizers (*Bradirhizobium* and PSM) and their interactions in groundnut in acid soils experiments on integrated nutrient management were taken at Manipur, Tripura and Barapani with cultivar ICGS 76.

In general very good response of *Bradyrhizobium* and PSM was noted with phosphatic fertilizer and lime at all the three locations in NEH Region. The soil amelioration with lime and P increased the productivity of groundnut (Table 1-3). The groundnut crop inoculated with PSM and *Bradyrhizobium* showed green canopy but the crop without *Bradyrhizobium* and PSM showed shunted growth with chlorotic leaves, poor nodulation and N and P deficiency symptoms.

At Tripura, addition of Lime + P + PSM gave 1794 kg/ha pod yield as against 1341 kg/ha in lime alone and 847 kg/na in control. However, Lime + PSM produced 1666 kg pod/ha. At Manipur application of lime alone increased 47% pod yield over control and 28% over chemical and bio-fertilizers. The pod yield obtained by lime+ PSM were at par with lime + P50. However, the maximum yield was recorded when the soil was limed along with P and K fertilizers. Nodule number and mass increased due to liming and P application and inoculation of *Bradyrhizobium* was more beneficial with P than without P.

At Barapani the pod yield was maximum 2250 kg/ha with inoculation of *Bradyrhizobium* over 20:60:40: NPK as against 2050 kg/ha with NPK and 1400 kg/ha in control. However the treatments FYM (10 t/ha), NPK+ *Bradyrhizobium* and NPK+PSM were at par and increased the pod yield in between 54-61%.

Table 3. Effect of various biofertilizers and inorganic fertilizers on the pod yield of groundnut cultivar ICGS 76 at Tripura during 1999

S.No.	Treatments	Yield (kg/ha)	Pod and Seed weight (g/plant)		
		Pod	Haulm	Pod	Seed
1	Control (P0L0)	847	1809	9.98	5.72
2	*Bradyrhizobium* (IGR 40)	904	2053	13.83	8.88
3	PSM (*Bacillus polymixa*)	836	1631	9.84	5.41
4	L2.5 (2.5 t/ha lime)	1341(58.3)	2129	12.64	7.96
5	T4 + *Bradyrhizobium*	988	2214	14.87	9.8
6	T4 + PSM	1666 (98.6)	2969	15.88	9.94
7	P50 (50 kg/ha P_2O_5)	743	1584	10.12	6.55
8	T7 + *Bradyrhizobium*	816	1906	9.45	5.77
9	T7 + PSM	693	1667	7.63	4.75
10	P50 + L2.5	1287	2694	12.70	8.36
11	P50 +L2.5 + *Bradyrhizobium*	1394	2878	12.81	7.05
12	P50 + L2.5 + PSM	1794(112)	3390	16.06	10.95
	LSD (0.05)	340	760	4.4	3.1

Figure in parenthesis is percent increase of mean yield over control

A. 4. Amelioration of Al-toxicity

A field experiment was conducted at Barapani to overcome the Al-toxicity through soil amelioration of various organic and inorganic fertilizers/amendments . Two years of study revealed that applications of NPK fertilizers, Lime and FYM increased the pod yield. Among these, application of lime was more beneficial as it increased the pH and thus increasing the availability of Ca, P and K (Table 4).

Table 4. Effect of various sources of nutrient on aluminium toxicity and pod yield of groundnut at Barapani during Kharif seasons (Cultivar ICGS 76)

S.No.	Treatment	Pod yield			
		1998		1999	
		kg/ha	% increase	kg/ha	% increase
1	Control	1550		1625	
2	FYM 10 t/ha	1983	27.9	2125	30.8
3	NPK 20:60:40 kg /ha	2083	34.4	2150	32.3
4	Lime 2 t/ha	2300	48.4	2271	28.4
5	FYM 10 t/ha+ lime 2 t/ha	2267	46.3	2500	35.0
6	NPK 20:60:40 kg /ha+ lime 2t/ha	2100	35.5	2950	81.5
7	FYM 10 t/ha+ NPK 20:60:40+ lime 2 t/ha	1950	25.8	3250	100
	Mean	2033		2410	

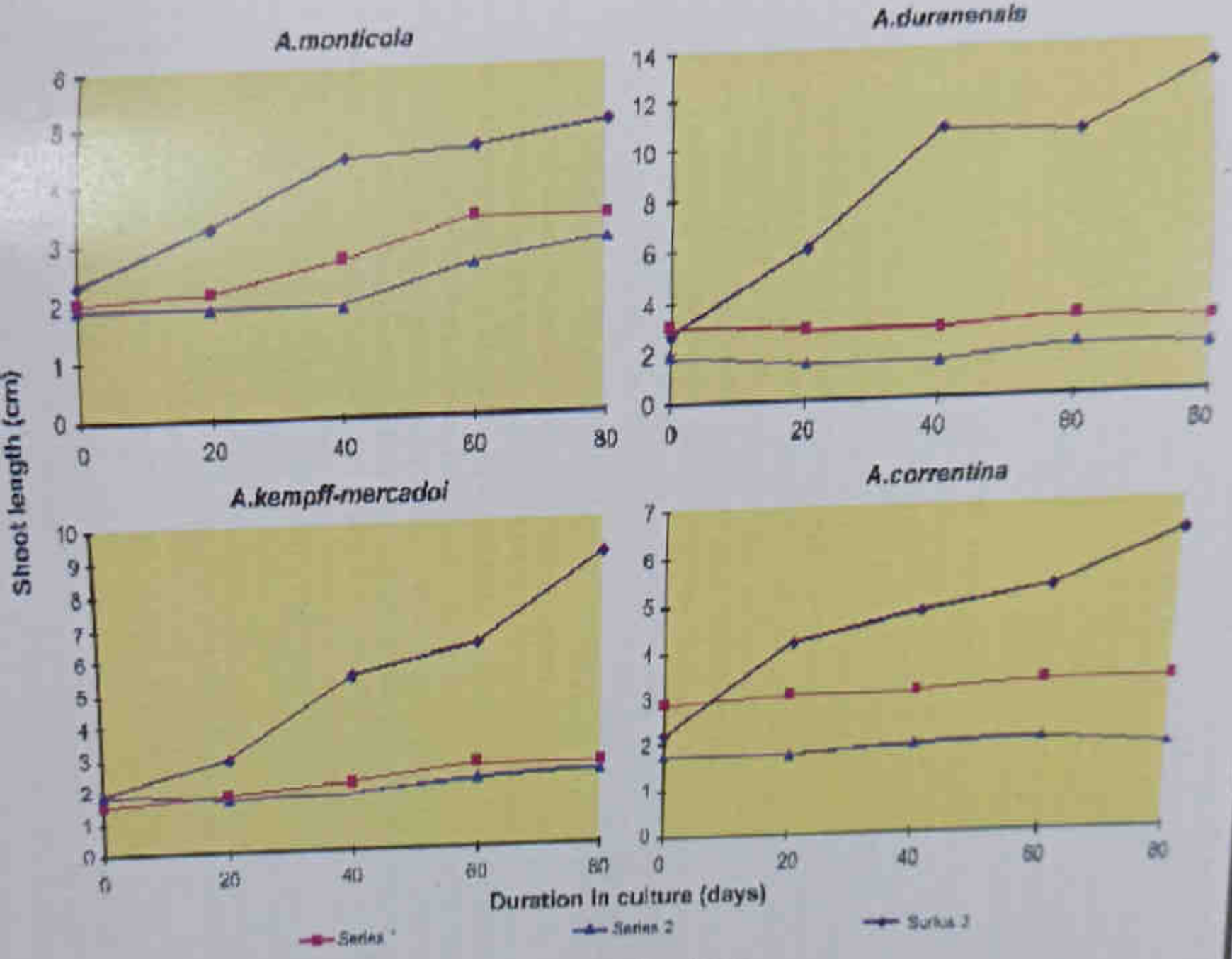


Fig 2. Growth rate of *in vitro* grown shoots of four *Arachis* species in different media
Series 1 : MS+5ppm BA Series 2 : MS+5ppm BA+2% mannitol ; Series3 : MS+5ppm BA+4% mannitol

Table 4. The present status of Germplasm holding

Place of storage	Nature of storage	Number of accession	Type of material
NRCG, Junagadh	Medium term storage	2100	Pods
-do-	Field	722	Rejuvenation/evaluation
-do-	Field gene bank	58	Wild species of Arachis
ORC, Bhubaneswar	Working collection	807	Pods/field
NBPGR, New Delhi	Base collection	3462	Pods
Total		7149	

Sub Project 2: *In vitro* conservation of groundnut germplasm (K. Chandran, K. Rajgopal.)

A. *In vitro* multiplication and conservation of wild *Arachis* germplasm

A. 1. *In vitro* multiplication

The de-embryonated cotyledons of seventeen accessions belonging to nine species of *Arachis* were cultured in MS medium supplemented with vitamins of B5 and 5ppm BAP. Profuse multiple shoots were produced which are maintained in the culture by frequent sub-culturing.

A. 2. *In vitro* conservation studies with slow growth protocol

Multiple shoots induced from de-embyonated cotyloedons of four species, *A.monticola* (8135), *A.duranensis* (8139), *A.correntina* (8918), *A.kempff-mercadoi* (8959) were cultured on MS medium supplemented with vitamins of B5 and 5ppm BAP and with different concentrations of Mannitol (0, 2, 4,and 6%). It is found that the MS medium supplemented with Mannitol retarded the growth of the shoots at 2 and 4%, but at 6% the shoots dried up due to high osmoticum. MS medium with 2 % mannitol was found better for *in vitro* conservation as the shoots maintained minimal growth (Fig 2.) with good vigour. The fresh weight and the dry weight of the shoots did not show any trend as with high concentration of mannitol induced more callus at the base of the shoots in some of the genotypes.

Sub Project 3: Enhancing the recombination frequency in groundnut (P.Manivel, R.K.Mathur and M.Y. Samdur)

To fulfill the objectives of the sub project three lines of approach have been chosen: i) enhancing the pollen sterility so that natural cross pollination is expectedly enhanced, ii) increase the success in artificial hybridization iii) increase the size of F2 population and thus enhancing the frequency of recombination events. The following are the experimentations with these approaches.

A. Induction of functional male sterility through spray of male gametocides

With a view to inducing functional male sterility for possible utilization in enhancing hybridization success in groundnut, three chemicals viz., indole acetic acid (IAA), indole butyric acid (IBA) and gibberellic acid (GA3) were experimented with. They were sprayed on three cultivars, JL 24, GG 2, and TG 26. The concentrations used were 200 & 400 ppm for IAA, and 300 and 600 ppm for IBA and GA3. First foliar spray was done at 40 days after sowing (DAS) and subsequent ones were done on alternate days up to 58 DAS. IAA and GA3 had given high pollen sterility. Maximum pollen sterility obtained with IAA was 28% and 50% with GA3 and 18 with IBA. However, plant-to-plant variation was quite high, the experiment needs modification by including wider range of doses of the three gametocides.

B. Genetics of male sterility

In the M2 generation of plants of Girnar 1 treated with chemical mutagens, DES and EMS, certain plants in plant-row progenies were isolated which could distinctly be characterized by small and round leaflets, reduced plant height and internodes but with normal flowering. These plants formed no pods. The remaining normal plants from the progeny rows with sterile plants were harvested individually and again sown in plant to row progeny in M3. In the M3 generation also we observed such plants. When the pollens of these plants was tested with acetocarmine straining and *in-vitro* pollen germination, it was found that all the pollen grains were sterile. Such male sterile mutants Girnar 1 ms, were crossed with three genotypes namely, Girnar 1, PBS 11023 (with dominant seed coat colour and stem pigmentation markers) and M 13 (a Virginia runner bold seeded cultivar). The F1's were evaluated during kharif 1999. All the F1 plants were of the fertile and towards pollen parent for all the traits with more hybrid vigour thus confirming the recessive nature of the gene in question for male sterility.

C. Optimization of time for flower removal to avoid selfing in artificial hybridization

During the artificial hybridization in groundnut neither all flowers can be used for hybridization nor it possible to continue till the plants goes on flowering. It is necessary to remove these flowers not used for hybridization so that the selfed pods from them do not mix up with hybrid pods.

Table 2. Distribution for qualitative traits among Bold seeded accessions

Traits	No. of accessions				
Growth habit	Decumbent 1	Decumbent 2	Decumbent 3	Erect	
	0	13	31	51	
Branching pattern	Alternate	Sequential	Irregular, without flowers on main stem	Irregular, with flowers on main stem	
	51	27	1	16	
Stem hairiness	Sub glabrous	Mod. hairy	Very hairy	Woolly	
	7	69	16	3	
Stem Pigment	Absent		Present		
	66		29		
Leaf colour	Yellowish green	Light green	Green	Dark green	
	2	32	60	1	
Leaf hairiness	Almost gla brous	Hairy below	Hairy below, with bristle	Very hairy	
	81	14	0	0	
Leaf shape	Lanceolate		Oblong		
	46		49		
Leaf tip	Acute		Obtuse		
	46		49		
Inflorescence	Simple		Multiple		
	66		29		
Flower colour	Orange	Dark Orange	Garnet		
	8	74	13		
Peg pigmentation	Present		Absent		
	11		84		
Pod size	Small	Medium	Large		
	0	77	80		
Pod beak	None	Sight	Moderate	Prominent	Very Prominent
	16	49	24	3	3
Pod constriction	None	Slight	Moderate	Prominent	Very Prominent
	1	62	22	10	0
Pod reticulation	Smooth	Sight	Moderate	Prominent	Very Prominent
	6	44	15	27	3

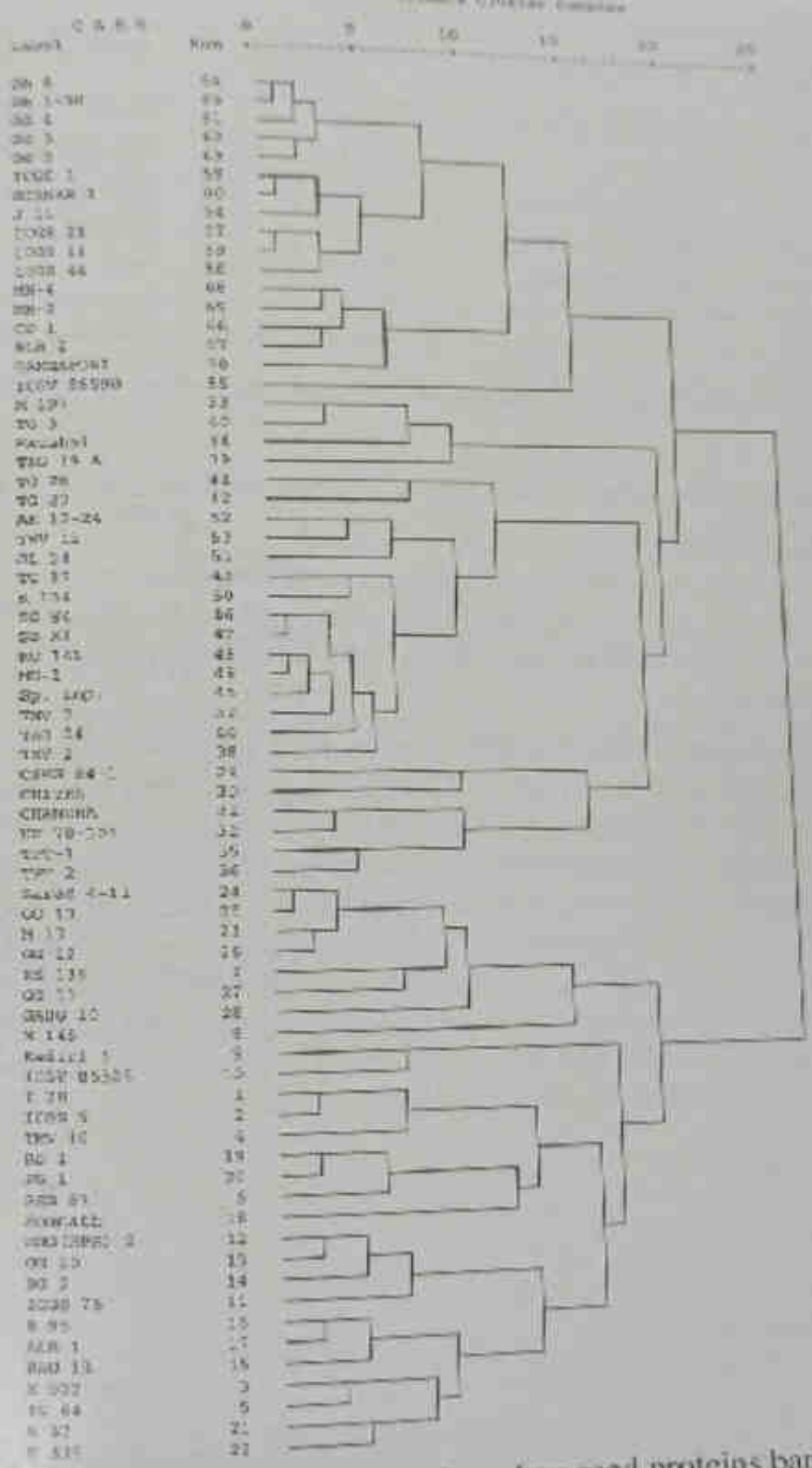


Fig 1. Dendrogram of 70 released cultivar based on seed proteins banding pattern

E. Screening of germplasm against foliar diseases

One hundred and thirteen germplasm lines were further screened against ELS, LLS and Rust, and the accessions identified as promising are NRCGs 10950, 11001, 11597, 11003, 11004, 11005, 11014, 11060, 11062, 11069, 11072, 11073, 11580, 11585, 11596, 11590, 11609, 11616. These lines showed the gradation scores of 7 to 9 for these diseases.

F. Evaluation of bold seeded germplasm

Ninety-five medium to large seeded accessions procured from ICRISAT were characterized for 17 qualitative and 31 quantitative traits and also to identify agronomically superior accessions for further utilization. The distributions for major qualitative traits are given in Table 2. The range mean and standard deviation for pod yield, shelling out-turn, sound mature kernel, hundred seed and pod weight are given in Table 3. The promising accessions with pod yield >100g.m2, shelling outturn >60%, sound mature kernel >80%, and hundred sed weight >55 g are NRCGs 11900, 11903 and 11952.

To identify promising large-seeded accessions (>45 g/100 seed mass) fifty accessions each of Virginia bunch and Virginia runner were evaluated during rabi season at Bhubaneswar.. Fourteen Virginia bunch, viz. ICG's 4442, 4804, 2485, 6098, 6453, 6790, 598, 4957, 6352, 1643, 6740, 4477, 6113 and 6742 and twenty Virginia runner accessions, viz. ICG's 840, 846, 863, 898, 901, 903, 916, 920, 921, 923, 928, 944, 957, 967, 1027, 1045, 1052, 6671, 2786 and 1019 appeared promising for 100 seed weight.

G. Identification of Virginia bunch accessions for short stature, and more number of primary branch

Out of one hundred and twenty six Virginia bunch accessions evaluated during rainy and post-rainy seasons at Bhubaneswar, eleven accessions, viz. ICG's 500, 4520, 4805, 5656, 11998, 1643, 2630, 2689, 6434 and 6740 appeared promising.

H. Screening of Virginia bunch accessions for resistance to termite

Out of one hundred and twenty six Virginia bunch accessions screened for termite resistance at harvest during rabi season at Bhubaneswar, no accessions showed complete resistance against termite damage. However, sixteen accessions viz. ICG 603, 1077, 2684, 2698, 4175, 4507, 4430, 4434, 4878, 4957, 4515, 6352, 6368, 7651, 11999 and 12127 registered less termite damage.

I. Evaluation of Virginia bunch accessions in rice fallows under residual moisture.

One hundred and twenty six Virginia bunch accessions were evaluated for higher pod yield, earliness and stable vegetative growth, during rabi season at Cuttack with control AK 12-24. The performance of five accessions, viz. ICGs 4515, 6098, 6739, 6794 and 11998 was better compared to local check. These accessions could be further tested for their performance to release as a cultivar for this region.

Table 3. Range mean and SD for yield related traits

Traits	Range	Mean	SD
Pod yield(g)/m2	10-132	71.2	26.9
Hundred pod weight (g)	79-180	113	18.3
Shelling out-turn (%)	39.2-72.0	59.8	6.1
Sound mature seeds (%)	63.8-96.7	85.4	7.3
Hundured seed weight (g)	40.0-66.0	46.0	5.9

J. Characterization of released cultivars

Seed proteins of seventy released cultivars were analysed by SDS PAGE for studying polymorphism. Difference in banding pattern was observed for high molecular weight proteins (126 and 113 kD) and low molecular weight proteins (between 30 and 7 kD). The banding pattern was analysed using pattern difference based on simple matching coefficient. The phenetogram based on the relationship is given in Fig 1. Three distinct grouping could be observed in cluster analysis. The first group consists of cultivars belongs to Spanish bunch type and Valencia. In the second group six cultivars belongs to virginia runner types (M 197, Kaushal, CSMG 84-1, Chitra, Chandra, UF 70-103 were grouped along with the remaining Spanish bunch cultivars, however no morphological similarities were observed for these cultivars with spanish bunch cultivars. The third cluster comprises cultivars belongs to Virginia bunch and Virginia runner types.

Further seventeen released cultivars acquired were characterized for 17 qualitative and 31 quantitative traits and 70 cultivars have already been characterized.

K. Documentaion

A compendium on elite germplasm was published and catalogues on 70 released cultivars and 700 germplasm accessions are in press. A database was prepared on conservation of germplasm in cold storage module for easy retrieval of the material.

L. Conservation of germplasm

The germplasm are maintained in base collection at NBPGR, New Delhi, NRCG, Junagadh in medium term conservation, field gene bank and at Outreach center Bhubaneswar. The present status of Germplasm holding is given in Table 4.

A pot experiment was conducted to find out the time of the day when the flowers that are not used for pollination (during artificial hybridization programme) have to be removed to minimize the chances of getting mixing up of selfed pods with hybrid pods. the removal of flower from the base along with the ovary was more effective than the removal from the top i.e. the floral whorl only in minimizing the selfed pegs per plant. To minimize selfed pods during artificial hybridization, the flower buds should be removed from the base in the evening or before 7 am during the kharif season in Junagadh like conditions.

D. Nodal culture for mass multiplication

One of the possible ways by which the size of the F2 population can be increased is the *in-vitro* mass multiplication of F1 plants. Of the *in-vitro* methods available the nodal culture is the simplest and cheapest method. When the ex-plants from field grown plants were used, major problems of fungal and bacterial contamination was noticed. Hence, an attempt was made using lab grown explants. The Spanish (*Arachis hypoguea* ssp. *fastigiata*) cultivar Girnar 1 and the Virginia (*Arachis hypogaea* ssp. *Vulgaris*) cultivar M 13 were used. The seeds of these cultivars were sown in plastic trays under laboratory conditions. Twenty-one days old seedlings were used for nodal culture. Apical nodal segments (2-4 cm) from plants were properly sterilized and grown in MS medium containing MS salts (Murashige and Skoog, 1962), 1 ppm NAA and 1 ppm GA3 and 20 g l-1 sucrose. Plants regenerated form nodal segment were moved to sand culture.

In both the cultivars rooting started after seven days of inoculations. A maximum of 63% nodes could be rooted in Girnar 1 and 71% in M 13. The percentage of rooting was higher in M 13 than in Girnar 1. The difference might be due to the alternate branching pattern of Virginia cultures. However, only about 50% of the rooted plants were established as full plant after transferring in to the soil. It was inferred from the present study that the from a single F1 plant about 6-8 plants may be obtained in a period of 50 days.

E. Heterozygous mutagenesis to increase the recombination frequency

One of the possible ways to increase the range of segregation is through the mutagenesis of heterozygous material. The F1 seeds of the cross GG 2 x Kadiri 3 was treated with 0.1% EMS and raised during kharif 1999 along with untreated F1 hybrid. For comparison, both the parents were also treated with same concentration of EMS and sown.

The variability studies in these treatments indicated that considerable variation was observed for most of the traits in treated populations than the untreated populations. Interestingly the variance was high in treated heterozygous populations that the untreated heterozygous and treated and untreated homozygous populations for most of the traits (Table 5).

Table 5. Variance in treated and untreated homozygous and heterozygous populations in groundnut

Parent/Hybrid	Plant height	Primary branches	Second-ary branches	No. of pods/ plant	No. of kernels/ plant	Total pod weight/ plant	Total kernel weight/ plant
GG 2	9.94	0.67	9.02	9.86	28.67	4.45	3.10
Kadiri 3	12.38	0.75	13.13	15.27	33.77	6.46	4.02
GG2 x Kadiri3	20.12	1.02	15.90	38.36	90.03	21.13	12.03
GG2 (T)*	12.58	0.91	8.90	10.94	31.85	6.71	4.26
Kadiri 3 (T)*	17.87	1.08	19.41	14.66	37.82	8.36	4.96
GG2 x Kadiri 3 (T)*	29.83	1.25	23.74	39.32	99.88	31.90	17.65

* T = Treated with 0.1% EMS.

E. 1. Standardisation of transformation protocols using mature seeds and zygotic embryos

De embryonated cotyledons and mature embryos were used for transformation using the *Agrobacterium* mediated method. The deembryonated cotyledons and the zygotic embryos were dissected out and co-cultured with bacterial culture after shaking with a small amount of carborendum. In both the cases 24 hrs coculture followed by 12 hrs co-culture on MS basal medium was done for infecting the explants with the bacteria for gene transfer. The explants were washed with Cephataxime before transfering to the multiple shoot induction medium. Random samples of the co-cultured embryos expressed the GUS gene in the radicle portion. Thus the bacterium could easily harbour in the vascular tissue of the radicle portion of the embryos. The de embryonated cotyledons after co cultivation were transferred to MS medium containing 15 ppm of BAP to induce multiple shoots.

The multiple shoots developed from these cotyledons were transferred on to a selection medium containing 50 ppm Hygromycin to select the putative transformants and two plants have been growing in the medium containing hygromycin for about a month, which are to be tested for the confirmation. The probable transgenics were transferred on to MS medium containing 15 ppm BA and 1 ppm of GA3 for further growth. This growth medium was supplemented with 50 ppm of hygromycin and 100 ppm of Cephataxime to ensure selection pressure and keep the plants free from residual Agrobacterium contamination.

E. 2. Utilisation of cut mature embryonic axes for transformation

Mature embryos were aseptically dissected out from the surface sterilised seeds of the cultivar GG 2. The embryonic leaves were removed from the embryo and the embryonic axes were separated. The removal of embryonic leaves induces more wounds at the apical region and the frequency of multiple shoots was more in such explants. These embryonic axes were co cultured with the *Agrobacterium* containing the plasmids of interest under shaking for 24 hrs. These materials were again co cultured on solid MS media for 12 hours. Then the explants were cleared off bacteria using washing medium containing Cephataxime for 6 hrs. The washed explants were then transferred on to MS medium containing 15 ppm of BA to induce multiple shoots. The explants induced multiple shoot buds and such plants are being screened in the selection medium with antibiotic pressure

E. 3. Utilisation of immature leaves for transformation

The immature leaves dissected out from the mature zygotic embryos of the cultivar GG2 were used for this experiment. The leaves were co cultured with *Agrobacterium* containing the recombinant plasmids of interest for 24 hrs in petri plates. The leaves washed with MS liquid medium containing Cephataxime for 6 hrs and cultured on MS

PROJECT 10: ASSESSMENT AND ENHANCEMENT OF QUALITY IN GROUNDNUT AND ITS VALUE ADDED PRODUCTS

Sub-project 1: Assessment of quality in germplasm collection, breeding material and produce of other experiments (J.B. Misra)

A. Assessment of quality of released groundnut cultivars

Seeds of 16 groundnut cultivars (1 Valencia, 5 Spanish bunch, 2 Virginia runner, and 8 Virginia bunch) grown in kharif 1998, were analyzed for protein, free amino acids, sucrose and reducing sugar contents and also for fatty acid composition (Table 1). The protein content ranged from 16.4 to 26.9%, sucrose from 4.67 to 9.24%, reducing sugars from 0.05 to 0.14%, free amino acids from 1.17 to 1.92% and the SI values from 1.15 to 2.95. Kernels of cv. BAU 13 were identified as high protein-high sucrose-high-SI kernels and that of cv. TMV 7 as high protein-low sucrose-low SI kernels. The kernels of cv. HNG(HPS 2) had relatively a high reducing sugar content.

B. The fatty acid composition, especially the ratio of oleic acid to linoleic acid (O/L ratio), determines the shelf-life of processed groundnut products.

This ratio is often termed as stability index (SI). The value of 1.6 or more for SI is considered desirable from the processing point of view. Fatty acid composition of another 18 cultivars (1 Valencia, 9 Spanish bunch, 3 Virginia runner, and 5 Virginia bunch) was analyzed (Table 2). The SI values ranged from 1.33 (TPT 1) to 3.69 (TG 22). The stability index values of virginia type cultivars were generally higher than those of the spanish types.

C. Improvement in the buoyancy of arachilipometer

The arachilipometer, which was developed earlier, with a cylindrical float, lacked perfect vertical buoyancy when floated in kerosene. With a view to improving the buoyancy, the float design was altered and a conical float, with its narrow end towards the lower side was fitted in the new model (Fig. 1). This new model showed near perfect vertical buoyancy, both with and without the sample-load. The model is now being calibrated.

D. Relationship between size of seed and its chemical composition

With a view to understanding bearing of seed-mass on its chemical constituents, the seeds of cultivars GG 2 and Girnar 1, falling in the weight class intervals of 90-110, 140-160, 190-210, 240-260, 290-310, 340-360, and 390-410mg were analyzed for their fatty acid composition and also for separation of their proteins banding pattern. The O/L ratio vlaue increased with the increase in seed-mass from 100 to 300 mg and then remained rather constant in case of cv. GG 2 while in case of cv. Girnar 1, there was no definite pattern (Fig. 2). PAGE of seed proteins showed that seeds of very small size lacked a few protein bands, which were otherwise conspicuous in the band-pattern of large seeds.

PROJECT 09: BIOTECHNOLOGICAL APPROACHES TO THE CHARACTERISATION AND GENETIC ENHANCEMENT OF GROUNDNUT

(Radhakrishnan T, P. Paria, Nandagopal, S. Desai, K. Chandran)

A. Morphological characterization of wild species of *Arachis*

Twenty-one accessions of thirteen *Arachis* species were characterized for stem hairiness, stem pigmentation, leaf hairiness, leaf colour, flower colour, petiole hairiness, length of hypanthium and length and width of standard petals. *A.batizocoi* and *A.cardenasii* showed yellow standard petal and in most of the *A.duranensis* accessions the pegs were green. Wide variance was found for most of the qualitative characters. The length of hypanthium and length and width of standard petals were very high in *A.paraguariensis*, *A.diogoi* and *A. stenophylla*. *A.paraguariensis* showed the maximum hypanthium length (9.5cm) and *A.villosa* the shortest (1.8cm).

B. DNA fingerprinting of the released varieties and enhanced germplasm of groundnut

Representative seed samples from seventy released cultivars were germinated in dark and from the etiolated plants leaf samples were collected for the isolation of genomic DNA.

Genomic DNA was isolated from two samples each from each of the cultivars. The samples were quickly frozen in LN2 and then extracted in a GIBCO BRL kit for genomic DNA isolation.

The DNA preparations were purified, estimated and stored for the fingerprinting and further characterization.

C. New hybridisations

Twenty-four crosses with ten marker genotypes were attempted and the probable hybrid pods were harvested with the objective of identifying morphological marker genes suitable for marker-aided selection (Table 1).

D. Standardisation of a protocol for somatic embryogenesis from immature leaves

The MS medium supplemented with 1 ppm NAA and 25 ppm 2,4-D was found optimal for somatic embryogenesis from immature leaf explants. The somatic embryos thus induced were regenerated to multiple shoots in MS medium containing 3 ppm BA and 1 ppm GA3. This protocol has advantage of producing somatic embryos for genetic manipulation studies, independent of the crop season

medium containing 25 ppm of 2,4-D and 1 ppm of NAA for somatic embryogenesis. The somatic embryos will be screened for the putative transgenics at the regeneration stage.

F. Screening of *Bt* proteins against leaf miner

Cry IAc protein was over expressed in E.coli bacterial cultures. The protein was isolated from the bacterial suspension by sonicating and the released *Bt* proteins were precipitated and purified. The protein in measured quantities were dissolved in solubilisation buffer and used for injecting the mines of leaf miner. The concentrations of 0.05, 0.1, 0.25 and 0.5 mg/ml were tried and the concentration 0.5 mg/ml was found to be inducing 100% mortality of the pupae.

Table 1. List of hybridizations attempted

1. Golden yellow leaf X Chocolate testa
2. Golden yellow leaf X Jamun testa
3. Golden yellow leaf X Deep constriction
4. Golden yellow leaf X Variegated testa
5. Golden yellow leaf X TMV NLM 2
6. Golden yellow leaf X Deep purple testa
7. Golden yellow leaf X Corduroy leaves
8. Golden yellow leaf X Puckered leaves
9. Puckered leaves X Deep constriction
10. Puckered leaves X Corduroy leaves
11. Puckered leaves X Long pod
12. Puckered leaves X Deep purple testa
13. Puckered leaves X Jamun testa
14. Deep purple testa X Jamun testa
15. Deep purple testa X Chocolate testa
16. Deep purple testa X Varigated testa
17. TMV NLM 2 X Deep constriction
18. TMV NLM 2 X Jamun testa
19. TMV NLM 2 X Corduroy leaves
20. TMV NLM 2 X Deep purple testa
21. TMV NLM 2 X Small leaves
22. Corduroy leaves X Small leaves
23. Corduroy leaves X Chocolate testa
24. Corduroy leaves X Jamun testa
25. Corduroy leaves X Deep purple testa

E. Utilisation of somatic embryos in the standardisation of transformation protocols

Somatic embryos from the cultivar GG2 were used in the *Agrobacterium* co-culture. The bacterium contained GUS and GFP reporter genes in addition to the *Cry1 Ac* gene from *Bacillus thuriengensis*. Somatic embryos were co-cultured for 24 hrs with the bacteria. The transient expression of GUS could be observed. Four plants are presently growing in selection medium containing hygromycin. These plants are being tested for the confirmation or the presence of the gene.

Table 2. Stability index of some released groundnut cultivars grown in kharif 1998 (source of material Genetic Resources Section)

	Cultivar	SI		Cultivar	SI
Valencia				**Virginia Runner**	
1	UF-70-103	3.84	11	Chandra	2.44
Spanish Bunch			12	RS 1	2.57
2	Dh3-30	1.48	13	GG 13	3.58
3	GG 3	1.41			
4	ICGV 86590	1.94			
5	TKG 19A	1.86		**Virginia Bunch**	
6	TMV 7	2.91	14	M 145	2.21
7	RG 141	1.42	15	ICGS 76	2.31
8	TG 17	2.08	16	T 28	2.61
9	TG 22	3.69	17	B 95	2.22
10	TPT 1	1.33	18	TG 64	1.94

Table 3. Quality traits of some advanced HPS breeding lines

Cultivar	Kernel yield kg/ha	100 seed mass g	Oil %	Stability Index	Protein %	Free amino acids %	Sucrose %
PBS 11039	1095 (5.2)	70.0	52.8	1.97	15.6	0.48	3.42
PBS 29017	1059 (1.7)	62.7	54.1	3.75	18.2	0.57	2.94
PBS 29033	1051 (1.0)	55.5	50.8	3.54	20.3	0.58	3.44
PBS 29035	1280 (23.0)	64.1	53.0	3.11	15.3	0.51	4.09
PBS 29054	1158 (11.3)	55.9	49.9	3.10	18.9	0.50	4.25
ICGV 89211	580	67.8	49.6	3.42	17.3	0.58	3.60
Somnath	1041	62.8	52.3	2.11	16.2	0.51	3.36
B 95	1025	67.7	49.3	2.68	16.4	0.51	3.05
LSD(0.05)	280	5.45	1.6	0.85	2.2	0.05	0.61

Values in parenthesis indicate improvement (%) over the best check Somnath

B. Effect of application of groundnut shell and inoculation of *Bacillus* for its *in situ* decomposition on growth and yield of kharif groundnut

Groundnut crop (cv. GG 2) was treated, either at the time of sowing or 30 days before sowing, with un-decomposed groundnut shell, with or without the inoculum of the organism *Bacillus sp.* for decomposition, at the rate of 0, 5, 10 and 15 t/ha. The time of application did not have any significant effect on any trait (table 5). However, the application of shell at the rate of 10 and 15t/ha significantly improved the pod yield (12.75% and 20.10%, respectively). For pod yield, only dose of shell appeared to be of significance and best was 15t/ha, irrespective of time of application and and inoculation. But for biomass and N content, the three-factor interaction was significant. The best combination for biomass was 15t/ha of shell application at the time of sowing in presence of Bacillus sp., for N content in plants its was 10t/ha when shell was applied at the time of sowing with inoculation *Bacillus sp.*, for N content in kernel it was the combined application of shell (5t/ha) and *Bacillus sp.* 30 day before sowing. But a discernible trend was that all three characters, inoculated shells @ 15t/ha applied before sowing was the best. Further experimentation will establish the trend.

Table 1. Quality aspects of some released cultivars of groundnut (kharif, 98)

Habit group	Protein %	Sucrose %	Reducing sugars (%)	Free amino acids (%)	Stability index
Valencia					
Gangapuri	17.4	7.82	0.05	1.53	1.15
Spanish Bunch					
CO 1	19.7	4.67	0.06	1.23	1.56
GG 2	21.8	6.68	0.05	1.26	1.21
ICGS 44	16.4	7.37	0.09	1.21	1.31
JL 24	18.0	5.36	0.07	1.39	1.33
TMV 7	26.9	5.61	0.05	1.43	1.18
Virginia Runner					
M 13	18.0	6.07	0.05	1.39	2.29
GG 12	21.2	8.07	0.06	1.38	2.00
Virginia Bunch					
BAU 13	23.9	7.50	0.06	1.80	2.89
GAUG 10	17.4	5.75	0.05	1.23	2.90
GG 20	16.4	6.46	0.05	1.46	2.55
HNG(HPS)2	18.0	6.71	0.14	1.56	2.95
J 11	18.5	7.31	0.09	1.81	1.24
Kadiri 3	18.1	6.54	0.06	1.27	1.20
Somnath	18.7	9.24	0.06	1.92	1.68
TMV 10	19.9	5.29	0.08	1.17	2.22
Minimum	16.4	4.67	0.05	1.17	1.15
Maximum	26.9	9.24	0.14	1.92	2.95
Mean	**19.4**	**6.67**	**0.07**	**1.44**	**1.85**
CD (0.05)	2.7	1.97	0.04	0.06	

E. Development of protocols for determination of methionine content in the seeds.
The minimum amount of composite meal (derived from a meal obtained by pulverizing 6-7 kernels) required for eliciting genotypic differences was worked out to be 200 mg. The meal, after defatting, could by digested and analyzed by the standard protocol.

F. Improvisation in the design of sample-cup of NIR spectrophotometer to reduce the sample requirement for determination of oil and protein contents.
The center already demonstratd the potential of NIR spectrometry for determination of oil content of groundnut kernels in a non-destructive manner. The main draw back of this technique is the much large quantity of sample (approx. 150g) that is required for this analysis than that required (10g) for analysis by the conventional Soxhlet method. To overcome this difficulty some improvisations were done in the sample cup to reduce the sample requirements. Using partitions made of non-glossy black card-board sheet, the volume of sample-cup was reduced to confine the sample in just a little more width than that of the optical path of the NIR transmittance spectrophotometer. The sample requirement was thus reduced to two-thirds (90g) of the otherwise required quantity (150g). The initial results were encouraging.

G. Service to other sections
Oil content of 1169 and 248 seed samples, received respectively form Genetic Resources and Plant Breeding sections was analyzed. Oil, protein, sucrose, reducing sugar, and free amino acid contents and also the fatty acid composition of 21 released varieties (received from Genetic Resources section) were analyzed. Fatty acid composition of 72 samples, and oil and protein contents of 40 seed samples, received from the Plant Physiology section, were analyzed

Sub-project 2:Genetics and Breeding for confectionery and HPS groundnut

(P. Manivel and J.B. Misra)

A. Hybridization: For developing genotypes with large-seed and superior quality traits, sixteen crosses were made in a line x tester mating design. These crosses will be evaluated in the next kharif season for agronomic and quality traits.

B. Generation advancement: A total of 30 crosses were made. Out of these 28 were made as 8 X 8 diallel set to study the genetics of seed size and related traits and were grown along with parents. The F2 progenies of three crosses, F3 progenies of 12 crosses, and F4 progenies of 12 crosses were also grown. From among the stabilized breeding material and germplasm lines, nineteen cultures showing traits desirable from confectionery point of view were selected for further use in hybridization programme.

C. Evaluation of advanced confectionery type breeding cultures for yield and nature of distribution of single seed mass in them: Thirteen advanced breeding lines and three reference cultivars (B 95 and Somnath, and ICGV 89211) were evaluated for their pod yield and quality traits in Kharif 99. On the basis of kernel yield, five breeding

Table 4. Effect of application of groundnut shell-compost on growth and yield of rabi-summer groundnut

Shell- compost applied (t/ha)	Pod yield (kg/ha)	Shelling turn-over (%)	Plant biomass (g/plant)	Nodule dry mass (mg/plant)	N in biomass (%)	P in biomass (%)
0 (control)	2062	64.50	16.09	46.50	2.13	0.128
5	2372	66.75	19.58	64.75	2.50	0.148
10	2425	67.25	21.96	69.75	2.59	0.151
15	2387	66.50	19.30	67.50	2.57	0.141
20	2352	66.00	19.26	73.50	2.53	0.136
25	2317	66.75	20.00	72.50	2.57	0.139
30	2387	67.00	19.41	74.50	2.51	0.139
CD(0.05)	101	2.15	1.23	10.46	0.115	0.019

Table 5. Effect of application of groundnut shell and its *in situ* decomposition by *Bacillus* sp. on growth and yield of kharif groundnut

Time and dose of application	Pod yield (kg/ha)		Plant biomass (g/plant)		N in plants (%)		N in kernel (%)	
30 days before sowing								
	GS	GSB	GS	GSB	GS	GSB	GS	GSB
0 t/ha	1283	1342	20.49	20.83	2.30	2.50	4.09	4.37
5 t/ha	1368	1385	23.35	25.19	2.38	2.60	4.44	4.51
10 t/ha	1358	1502	25.92	31.92	2.47	2.60	3.99	3.75
15 t/ha	1405	1590	26.89	29.69	2.63	2.60	4.13	3.99
At the time of sowing								
0 t/ha	1168	1178	16.68	18.75	2.27	2.50	3.60	3.95
5 t/ha	1220	1314	23.73	27.11	2.50	2.33	4.20	3.95
10 t/ha	1343	1402	26.41	26.63	2.50	2.63	4.10	4.50
15 t/ha	1419	1556	31.61	34.26	2.33	2.20	3.85	4.27
LSD(0.05)								
A. Time	NS		NS		NS		NS	
B. Dose	154		NS		0.08		0.06	
C. Inoculation status	NS		1.97		0.47		0.07	
A x B	NS		NS		NS		0.08	
A x C	NS		2.78		NS		0.10	
B x C	NS		3.94		0.09		0.14	
A x B x C	NS		5.57		0.13		0.20	

GS= Groundnut shell; GSB= Groundnut shell + *Bacillus*

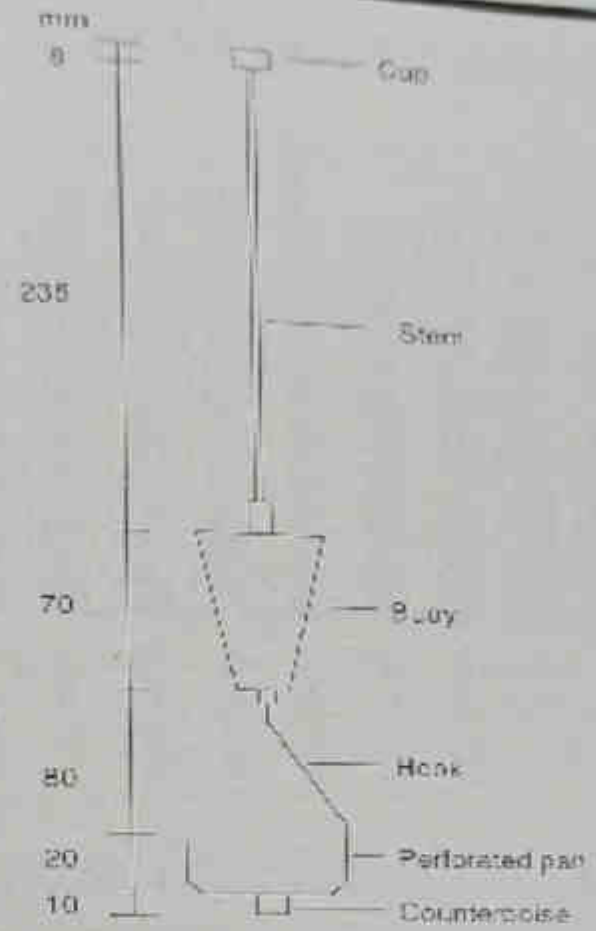


Figure 1. Line diagram of the arachi pe meter with improved float design

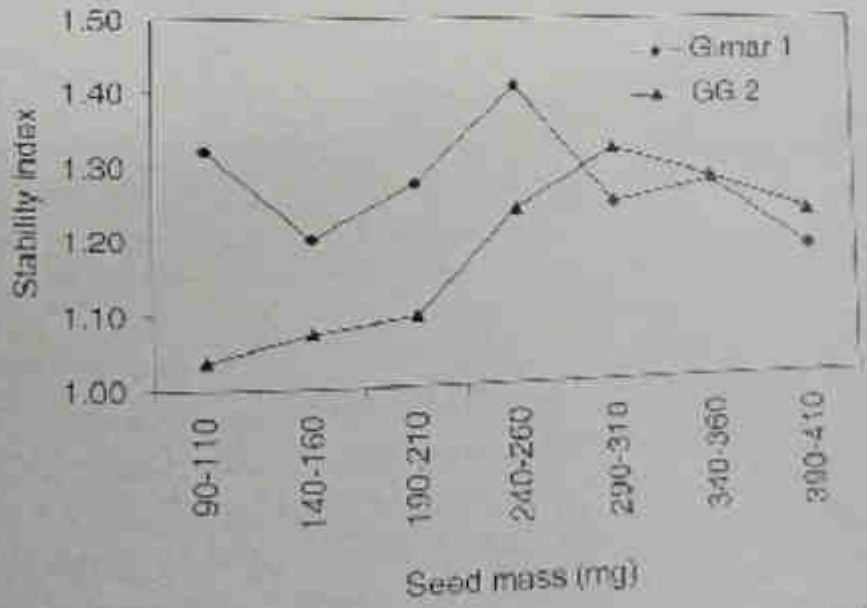


Figure 2: Relationship between seed mass and stability index

lines viz. PBS 11039, PBS 29017, PBS 29033, PBS 29035, and J-12 B-2 were identified to be superior to the best reference material Somnath. The kernel yield and some quality traits of these 5 cultures are presented in table 3. The stability index (stability index = O/L ratio) values of four lines, viz. PBS 29017, PBS 29033, PBS 29035, and PBS 29054 was greater than 3 whereas one of them viz. J-12 B-2 had the lowest oil content (50%) and the highest sucrose content (4.3%). The breeding lines and the check cultivars did not differ much in their amino acid content while the protein content of PBS 11039 and PBS 29035 was quite low. A combination of low oil content, high protein content and high SI values and high sucrose content makes a genotype desirable from the processing point of view.

The distribution of Individual seed mass was studied in a random sample of 1000 seeds for each of 13 breeding lines and three cultivars. Mean, mode and median of the distribution for each of the 16 genotypes are shown in figure 3. The breeding lines PBS 11039, 29026, 29031, and 29035 were found to have a greater proportion of large seeds.

Sub-project 3: Biotransformation of groundnut shell into useful products

(R. Dey, K.K. Pal, J.B. Misra)

Incorporation of crop residues for preserving soil fertility is an age-old practice and the concept of organic recycling is gaining grounds anew. However, the groundnut shell, which contains about 65% cellulose and small quantities of minerals, is generally not used as a manure as it cannot be decomposed. But the potential of groundnut shell as manure may be realized, if the rate of decomposition is enhanced by employing cellulolytic capabilities of some micro-organisms and this can be achieved by incorporation of suitable microorganism for either composting or in-situ decomposition of shell in the fields. Accordingly, experiments were conducted to test both of these approaches.

A. *Bacillus* sp. mediated composting of groundnut shell and effect of its application on the yield of rabi-summer groundnut

Groundnut shell, supplemented with urea @ 200 g/q of shell and inoculated with *Bacillus* sp. was subjected composting. Composting was carried out in pucca (cemented) pits for 90 days. The compost thus formed was applied at the time of sowing at the rate of 5, 10, 15, 20, 25 and 30 t/ha in the groundnut crop (cv. GG 2) in rabi-summer, 1999. The application of shell compost in all doses significantly improved all the traits studied over control (Table 4). Pod yield was improved by 17.6% (10t/ha) over the control, nodule dry weight by 37.6% (30t/ha), plant biomass by 36.5% (10t/ha), and shelling turn-out by 4.3% (10 t/ha). Whereas nitrogen and phosphorus contents in the plant biomass showed an increase by 21.6% (10t/ha) and 18.0% (10t/ha), respectively. However, differences due to the dose of application (5-30t/ha) were not statistically significant though the dose 10t/ha appeared to be the best numerically. Further testing is required.

(295, 390), three isolates of *T. viride* (APDRC3, APDRC4, Bca6) and two isolates of *Trichoderma sp.* (MPH, Ananthpur) could overgrow the colony of *A. flavus*. Two isolates of *T. harzianum* isolates (144, 295) and one *T. viride* isolate (TV4) inhibited the growth of *A. flavus* by producing zones of inhibition. None of the isolates produced any volatiles but three isolates produced non-volatiles in vitro. All the isolates were susceptible to the fungicides thiram and bavistin, but, *T. viride* (Bca6) and Trichoderma sp. (MPH) tolerated up to 50 mg/L thiram. Genomic DNA from these isolates has been isolated for RAPD fingerprinting of these isolates by using random primers.

For general as well as selective monitoring of either the biocontrol agent or the pathogen, suitable marker traits are required. Generally, *A. flavus* can tolerate slightly higher concentrations of benomyl as compared *Trichoderma* spp. The ability of AF 11-4 strain of *A. flavus*, to tolerate benomyl was investigated. Benomyl was amended to PDA at 1, 2, 4, 6, and 8 mg/L concentrations and the plates were inoculated with 5mm dia discs of *A. flavus* cut from the actively growing regions of the colonies. As seen from the table 4, *A. flavus* could tolerate up to 2 mg/L of benomyl, slightly higher than Trichoderma. Hence, it may not be useful as a marker to monitor the populations in the soil.

Table 3. Sensitivity of *A. flavus* to Benomyl

Benomyl concentration (mg/L)	Mean* colony dia (cm)
0	4.2
1	3.8
2	2.9
4	0.8
6	0.0
8	0.0

* Mean of four replicates

A near UV lamp (364 nm) was used for irradiating the spore suspension of *A. flavus* and *Trichoderma* spp. (MPH) for induction of selectable marker traits. An apparent spore colour mutant has been isolated and is being studied further for the stability of the trait.

As artificial diet for bruchid larvae is not available, a novel bioassay technique was developed. Rifampicin resistant mutants were force-fed to the young larvae. The mortality rate was counted and Bt were reisolated from the dead larvae using rifampicin resistant marker. The technique proved very efficient in bioassays suggesting the entomopathogenicity of the Bt isolates.

Cultural conditions for optimization of the Bt spores and toxin production have been determined. The best conditions are when glucose is used as the carbon source, ammonium sulphate as the nitrogen source, glutamate and aspartate as amino acid sources, the pH is 7.2 and the maximum temperature is 30-35°C for most of the isolates. Under these optimum conditions, isolates start producing insecticidal crystal protein (ICP) after 28-30 hrs of growth. Besides, protocols were standardised for estimation of insecticidal protein and plasmid profiles of the Bt isolates. Subsequently, plasmids and ICP were isolated from different efficient strains and purified for determining the nature of crystal protein and plasmid profile of the isolates.

Parasitoid: The parasite, *Anisopteromalus calandrae* (Howard), is highly potent in parasitizing the pupa (Plate 2). A natural parasite, which was earlier identified as pupal parasite, was found to parasitise the confiscated larvae within the infested kernels. The parasite could kill the insect larvae even in the first instar stage with more than 90% efficiency (Table 3). When such infested kernels were mixed with healthy kernels in the ratios 1:10 to 1:1000, the parasite could still locate and identify the only infested kernel in the heap of the 10-1000 healthy kernels and kill the confiscated larvae (Table 7). But if the hatched egg-shells were removed from the infested kernels, *A. calandrae* could not identify the infested kernel and in that case the confiscated larvae remained alive. *A. calandrae*, probably, identifies the infested kernel and confiscated larvae by identifying the egg and site of oviposition. It has been observed that the parasite lays eggs either on the pupae or on the confiscated larvae within the infested kernels. During oviposition it also discharges some toxin into the insect body, which causes the death of the insect. The larvae of the parasite survive saprophytically on the body of the dead insect. The secretion of the poison sac, present in the parasite, which is discharged

Plate 2. *Anisopteromalus calandrae* parasitizing pupa of bruchid butia (*Caryedon serratus*)

into the insect body, generally contains a mixture of proteins and certain enzymes. Attempts are being made to understand the nature of this protein and enzymes produced in the parasites' poison sacs.

PROJECT : IDENTIFICATION OF EFFICIENTLY NODULATING AND NITROGEN FIXING STRAINS OF BRADYRHIZOBIUM IN GUJARAT AND THEIR APPLICATION

(K.K. Pal, Rinku Dey and P. K. Ghosh)

Nodulation by ineffective but generally more competitive native bradyrhizobial population is a major obstacle for rhizobial strain development efforts. More so in groundnut which is highly promiscuous with respect to nodulation by bradyrhizobial species. Thus, there is an urgent need for identification of efficient strains of bradyrhizobia with competitiveness traits which can nodulate groundnut much more frequently than the native bradyrhizobial strains. To select efficient strains of *Bradyrhizobium* with desirable competitiveness related traits and high BNF efficiency from among the strains available in Gujarat soils is the aim of this project.

From the nodules and soil samples collected from different parts of the Saurashtra of Gujarat, 263 different isolates of *Bradyrhizobium* were obtained. The isolates differed in the colony morphology (rough, smooth) and types (excessive gum producing: both loose and tenacious). The isolates have been purified further and were tested for competitiveness traits like siderophore production (plate 3), antibiosis (plate 4) and bacteriocinogeny under laboratory conditions. Among these isolates, 87 isolates produced siderophore and 23 showed antibiosis property. A growth chamber experiment was conducted to test the efficiency of the isolates having competitiveness trait(s) for nodulation. Sixty-three isolates were found to be very efficient in nodulation in growth chamber experiments. Nodule occupancy rate is a measure of relative competitiveness of the rhizobial strains. To study the nodule occupancy under natural soil conditions, spontaneous rifampicin resistant mutants of 39 isolates were developed and were tested in pots. Nodule occupancy was evaluated at 30 days after sowing onto YEMA containing rifampicin (100ug/ml) keeping NC92 strain of *Bradyrhizobium* spp. as known control. Results (Table 4) indicated that While NC92 occupied 18% of the total nodules, newly isolated strains of bradyrhizobia viz., NRCG 1, NRCG 2, NRCG 3, NRCG 4, NRCG 5, NRCG 6, NRCG 7, NRCG 8, NRCG 9, NRCG 10 and NRCG 11 occupied 62%, 67%, 63%, 69%, 65%, 66%, 69%, 59%, 57%, 63% and 55%, respectively, of the total nodules at 30 DAS respectively, of the total effective nodules at 30 DAS (Table 8). The efficient strains are now being tested in pots for plant growth promotion, nitrogen fixation and yield.

PROJECT 11: PREVENTION AND MANAGEMENT OF MYCOTOXINS IN GROUNDNUT (S. Desai and M.P. Ghewande)

A. Management of pre-harvest *Aspergillus flavus* infection and aflatoxin contamination

A. 1. Intercropping groundnut with different crops

Five crops viz. pigeonpea (cv. BDN 2), pearlmillet (cv. MH169), sorghum (cv. local), cotton (cv. Hybrid 8), and castor (cv. GCH 4) were evaluated as intercrops during kharif 1999 for the management of pre-harvest *A. flavus infection* and subsequent aflatoxin contamination. Each plot had four rows of intercrop and nine rows of groundnut and the intercrops were sown with groundnut in a 1:3 ratio. Each treatment was replicated three times. The inoculum of *A. flavus* was incorporated along the rows at flowering of groundnut @ 1x106 cfu/ml and one litre inoculum suspension per row of 5 m length. Observations were recorded on final plant stand, pod yield, yields of intercrops, infection and colonization by *A. flavus*. Though, percent infection and colonization vary across treatments significantly, no particular trend could be observed (Table 1). In Groundnut+Pigeonpea, seed infection was the least (13%) but seed colonization was the least when groundnut was intercropped with either sorghum or cotton (5%).

Table 1. Effect of intercropping of groundnut on pod yield, shelling outturn, infection and colonization by *A. flavus*

Treatment	Pod yield (kg/plot*)	% Shelling outturn	Infection by *A. flavus* (%)	Colonization by *A. flavus* (%)
Groundnut + Pigeonpea	1.17	74.0	13	8
Groundnut + Pearlmillet	0.66	72.7	23	8
Groundnut + Sorghum	0.82	72.0	18	8
Groundnut + Cotton	1.24	69.3	23	5
Groundnut + Castor	0.82	74.0	23	5
Sole groundnut	2.03	72.3	30	8
C.D. (p=0.005)	0.25	2.40	1.81	1.51

* Plot size: 29.25 m²

A. 2. Induction of resistance:

During kharif 1999, effect of salicylic acid in inducing resistance against infection by *A. flavus* was assessed in a rain-out shelter using a resistant cv. J 11 and a susceptible cv. GG 2. Salicylic acid sprayed once at flowering at 7, and 12 mM concentrations and compared with no spray and water spray. In all the plots, inoculum of *A. flavus* was incorporated along furrows at flowering at a concentration of 1x106 cfu/ml and a volume of 600 ml inoculum suspension per row of 3 m length. Soil-moisture-deficit stress was

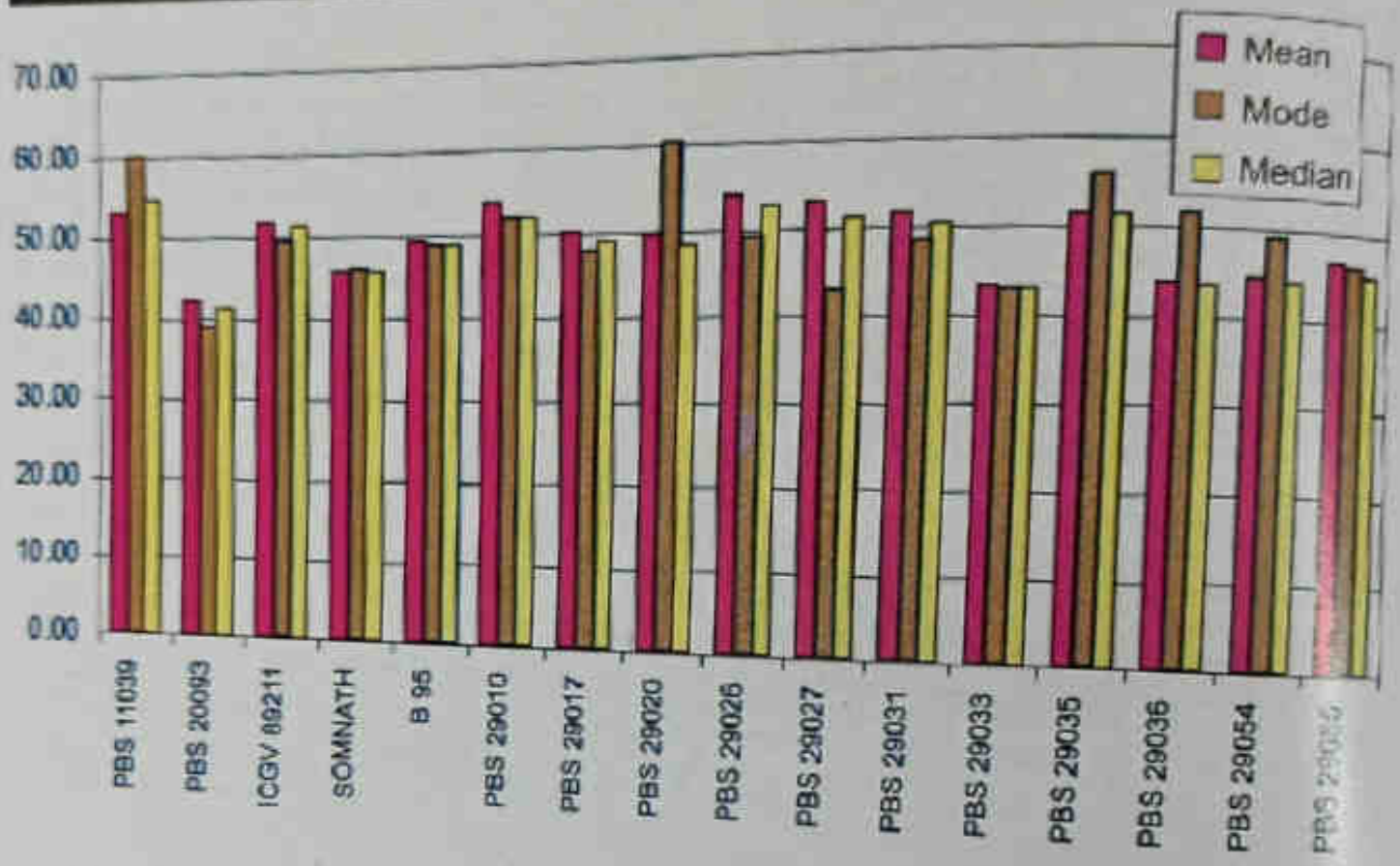


Figure 3. Mean mode and median for single seed weight in different advanced breeding lines.

EXTERNALLY FUNDED PROJECTS

PROJECT : IDENTIFICATION AND EVALUATION OF BIOPESTICIDES EFFECTIVE AGAINST THE STORAGE PEST OF GROUNDNUT BRUCHID BEETLE (CARYEDON SERRATUS OLIVIER (K.K. Pal and Rinku Dey)

The bruchid beetle, *Caryedon serratus*, causes considerable damage to groundnut, stored with farmers, traders, and millers all over the country and even the export of groundnut has also been reported to be affected. The project aims at developing effective biocontrol agents to manage bruchid infestation.

Microorganisms: From the naturally dying populations of bruchid larvae and adult, around fifty different isolates of bacteria and fungi were identified having potent larvicidal activity. On the basis of the larvicidal potency, five *Bacillus thuringiensis* (*Bt*) isolates were taken for studying the efficiency in controlling bruchid beetle. *Anisopteromalus calandrae*, a parasitoid of bruchid was also tested. Experiments were conducted for studying the efficiency of the *Bt* isolates and *A. calandrae*, alone and in combinations with different methods of formulations. Application of the isolate DHL1 could reduce the loss of dry kernel mass from 66% in control to 30% (Table 1) and was the best among the isolates in killing the young larvae. Dual application of *Bt* (isolate DHL1) and *A. calandrae* effectively controlled the population of bruchid as the pupae which escaped *Bt* were killed by *A. calandrae*. The mortality of the pupae due to parasitization by *A. calandrae* was 40-82% (Table 2). The significance of the result is that the combined application of Bt and *A. calandrae* could prevent the subsequent generations of bruchid and will be able to minimize the loss.

Application of Bt to the stored product is a major problem which is further complicated when the insect feeds inside the pods. To carry the population of Bt and crystal protein onto the surface of the kernel, a novel approach was employed. Rifampicin resistant mutants of a Bt isolate DHL1 have been identified and applied into the soil to allow the organisms to colonise the surface and the inside of the pod. The application of five such mutants of the isolate DHL1 were made at 60 days after sowing to the groundnut, cultivar GG 2. The population densities of the mutants, on the surface and inside the pod, were monitored periodically to ascertain the multiplication and effect on other beneficial microbial population. It was found that Bt could colonise the geocarposphere of groundnut very effectively and established a population density of 5.6 X 10^{6} on the surface of the pods and 1.3 X10^{7}/g inside of the pod. However, application of Bt did not affect the population of beneficial microorganisms. Experiments are now on to evaluate the incidence and loss of the pods due to bruchid infestation, if any, following *Bt* application.

also imposed at flowering stage. At harvest, observations were recorded on pod yield, fodder yield, percent infection and colonization by *A. flavus*. No significant trend was observed for per cent infection and colonization by *A. flavus* (Table 2) excepting that GG 2 more affected than J 11 which is a proven source of resistance. Similarly, J 11 yielded higher than GG 2 across the treatments.

B. Laboratory trials

Dual culture studies with 55 isolates of Trichoderma spp. were conducted in vitro to identify strains effective against *Aspergillus flavus*, *Sclerotium rolfsii* and *A. niger*. Interaction of 16 isolates of *Trichoderma* spp. with three pathogens has been summarized in Table 3. Among these isolates, *T. hamatum* (T043) and *Trichoderma* sp. (425) were effective against all the three pathogens.

Table 2. Effective strains of Trichoderma spp. against soil-borne plant pathogens

Isolate No.	Trichoderma spp.	*A. flavus*	*A. niger*	*S. rolfsii*
T004	*T. hamatum*	+	-	-
T040	*T. harzianum*	+	-	-
T043	*T. hamatum*	+	+	+
T049	*T. hamatum*	+	-	-
T071	*T. koningii*	+	-	+
T095	*T. hamatum*	+	-	+
T126	*T. harzianum*	+	-	-
T144	*T. harzianum*	+	-	-
T191	*T. viride*	-	-	+
144	*T. harzianum*	-	-	+
T166	*T. harzianum*	+	-	-
T250	*T. harzianum*	+	-	-
T295	*T. harzianum*	+	-	-
357	*T. hamatum*	+	-	-
390	*T. harzianum*	+	-	+
425	*Trichoderma sp.*	+	+	+

Thirteen out of these 16 cultures along with 13 more isolates of *Trichoderma* spp. from ICRISAT were characterized for their biocontrol ability against *Aspergillus flavus* and other desirable traits. These isolates represented *T. viride*, *T. harzianum*, *T. hamatum*, *T. longibrachiatum* and *T. auroviride*. The isolates differed significantly for their growth (Table 3). Maximum mycelial dry wt. of 0.37g was produced by isolate *T. viride* (NARP isolate) followed by *T. harzianum* (APDRC 19). *T. hamatum* (T049) had the least growth. In a dual culture study *in vitro*, among these 26 isolates, two isolates of *T. harzianum*

Plate 3. production of siderophore by *Bradyrhizobium* isolate

Plate 4. Antibiosis of native *Bradyrhizobium* by a competitive and efficient strain of *Bradyrhizobium*

Table 1. Evaluation of Bt isolates for controlling bruchid incidence in groundnut, cultivar GG 2*

Treat.	Initial kernel wt. (g)	Final kernel wt. (g)	% weight loss	Average number of eggs/ 50 pack	Average number of eggs hatched/ 50 pack	No of adult + larvae/ 50 pack	No of dead larvae / 50 pack
Control	30.01	10.40	66.23	81.00	75.33	67.33	8.00
DHL 1	28.06	19.79	29.96	67.66	66.00	34.00	32.00
BLN3	28.58	14.98	47.35	62.00	60.66	49.00	11.66
SILN1	29.05	16.90	41.80	58.66	55.66	43.33	12.33
HBN1	28.83	15.79	44.55	54.66	50.00	38.66	11.34
HBN2	27.57	13.08	52.74	53.33	48.66	41.33	7.33

*Average of three replications, 50 pods/pack, 4 pairs of adults released, incubated for 50 days

Table 2. Evaluation of Bt isolates in combination with *A. calandrae* for controlling bruchid in groundnut, cultivar GG2*

Treat.	Average number of eggs/ 50 pack	Average number of eggs hatched/ 50 pack	No of adult/ 50 pack	No of live pupae / 50 pack	No of dead pupae / 50 pack	No of A. calandrae emerged	Mortality %
Control	199.33	195.66	91.33	33.67	2.33	0.00	6.47
DHL 1	153.33	150.33	18.00	06.00	28.00	28.00	82.35
BLN3	194.66	191.33	46.67	19.33	15.67	15.00	44.77
SILN1	204.66	201.66	35.33	19.33	17.66	20.00	47.73
HBN1	190.33	187.00	44.00	16.66	11.33	16.00	40.47

*Average of three replications, 50 pods/pack, 4 pairs of adults released, incubated for 50 days; two pairs of *A. calandrae* released after emergence of Ist pupa in the pack

FARM

During the period under report various works including developmental attended by the farm section are described herewith

- A total area of about 52 ha in kharif 1999 and 2.00 ha in R/s 1999-2000 was covered under experiments and land utilization programme. Area under experiments, general crop were 12, 42 ha. respectively.
- An area of about 6.0 ha was developed and brought under cultivation.
- Keeping in view the drought situation the pond No.1 was deepend (about 2800 cu mtrs) to enhance the storage capacity of the pond. A submercible pupm was commissioned into the bore at the bottom of well no.2 to get more water for irrigation. A water tanker got fabricated for providing point source irrigation to agro-forestry plantation, boundary plantation and as well small experiments.

LIBRARY

- Our centre's library subscribed 24 International and 47 Indian journals, 5 news papers and acquired 9 serials, 20 books and one report. The library facilities were extended to various research and development organizations.

Database/Networking

- Bibliographical search of the CAB-CD databse on CD for the period 1973 to 2000 and AGRIS-CD for the period 1975 to 2000, is made available on local area network.

Table 3. Efficiency of *A. calandrae* to detect the infestation in kernels and efficacy of killing the confiscated larvae*

S. No.	Treatments (ratio of infested : healthy kernels)	Total eggs of bruchid	No. of dead larvae	No. of live larvae	Number of A. calandrae emerged	Efficiency (%)
1	1:1000	3	2	1	0	66
2	2:1000	6	4	2	0	66
3	5:1000	15	12	3	0	80
4	10:1000	30	26	4	1	86
5	2:100	6	5	0	1	100
6	5:100	15	12	3	2	80
13	10:100	30	27	3	3	90
14	0:100 (control)	0	0	0	0	-

*Two pairs of *A. calandrae* were released in each treatments just after hatching of the eggs of bruchid

Table 4. Nodulation patterns and nodule occupancy of some bradyrhizobia isolates obtained from different places of the Saurashtra region of Gujarat.

Isolates	Total number of active nodule/ plant	Nodule occupancy of the inoculants strains (%)
NC92	39	18
NRCG1	63	62
NRCG2	73	67
NRCG3	55	63
NRCG4	47	69
NRCG5	49	65
NRCG6	41	66
NRCG7	53	69
NRCG8	38	59
NRCG9	41	57
NRCG10	40	63

Nodule occupancy on the basis of spontaneous rifampicin resistance (10 best isolates only) at 30 DAS

Project: Mass multiplication of biocontrol agents for the management of late leaf spot of groundnut in Mahboobnagar and Nalgonda districts of A.P.

The project is being run in collaboration with the Regional Agricultural Research Station, Acharya NG Ranga Agricultural University, Palem. During Kharif 1999, a field trial was conducted at RARS, Palem for the management of late leaf spot using the fungi *Penicillium islandicum* and *Verticillium leecani* and their culture against national recommendation of fungicidal spray i.e. 3 sprays of carbendazim and dithane M-45. It appears that these biocontrol agents could not show the desired effects. Another naturally occurring mycoparasite has been isolated. Efforts were made to establish a culture of late leafspot fungus to facilitate conducting of in vitro trials.

PROJECT: Technology Assessment and Refinement Through Institution-Village linkage programme (TAR-IVLP) (Dr. M. P. Ghewande Dr. Devidayal, Dr. V. Nandgopal, Dr. R.K. Mathur, Shri Satishkumar, and Dr. K. S. Murthy)

Integrated Nutrient Management (INM) in Groundnut + Pigeonpea intercropping system

In groundnut + pigeonpea intercropping, application of recommended doses of NPK through single super phosphate (SSP), muriate of potash (MOP) and ammonium sulphate (AS) with 500 kg/ha gypsum along with phosphorous solubilizing microorganisms (PSM), gave much higher yield of pigeonpea (736.22 kg/ha) than the farmers' practice (529.94 kg/ha). The maximum pod yield of groundnut (483.34 kg/ha) was with recommended NPK. The gross monetary return of the system as a whole was higher (Rs. 21384/ha) in the treatment where the recommended NPK with gypsum and PSM were applied than farmers' practice where a gross return of Rs. 17360/ha was realized.

Integrated Nutrient Management (INM) in Groundnut + Castor intercropping system

The results of INM in Groundnut + Castor intercropping system showed that application of recommended NPK increased pod yield of groundnut by 12.5 %, than farmers' practice. Addition of gypsum and PSM, further increased the pod yield by 115 kg/ha over the recommended NPK. This was 30.7 % higher than the farmers' practice. However, there was no improvement in the yield of castor. The gross monetary return of the system was higher (Rs.26893/ha) in the treatment where the application of recommended NPK and addition of gypsum and PSM was done as compared to farmers' practice (Rs. 23269/ha).

Integrated Pest Management (IPM) in Groundnut

The verification trial on IPM showed that there was an improvement in initial plant stand by 6 % and reduction in defoliators by 27 %, early leaf spot by 33 %, late leaf

spot by 32 %, rust by 39 %, collar rot by 21 %, stem rot by 31 %, and PBND by 49 % where IPM components (seed treatment with carbendazim(2g kg/seed), foliar spray of neem oil(2%), use of biocontrol agent (*Trichoderma viride* 62.5 kg/ha), soil amendment with castorcake(1000 kg/ha), use of barrier crop, and use of pheromone traps) were used over farmers' practice. The male moths of *Spodoptera* and *Heliothis* trapped were 17 and 14 /trap/week, respectively in IPM treatment. This resulted in increased in pod yield of groundnut by 21 % (1862.46 kg/ha) over the farmers' practice (1535.74 kg/ha). The additional income from pigeon pea was also realized and gross income of Rs. 59827/ha was obtained as against farmers' practice (Rs. 27643/ha).

Integrated Management of stem rot and collar rot Diseases in groundnut

The on farm trial (OFT) on Integrated Management of stem and collar rot diseases indicated that, there was an increase in plant stand by 5 to 9 % in all the treatments over farmers' practice . Application of castor cake @ 1000kg/ha gave maximum control of collar rot (62.28 %). While in the case of stem rot , soil application of castor cake + *Trichoderma viride*, a biocontrol agent @ 62.5 kg/ha, or castor cake alone were equally good for the control (62-63%) of stem rot over farmers' practice. Gross monetary return was the highest in the treatment of Castor cake + *Trichoderma viride* (Rs.15782/ha) followed by castor cake (Rs. 15666/ha) and *Trichoderma viride* (Rs. 15202/ha) as compared to farmers' practice (Rs.14196/ha).

Farmers Training

A farmers' training programme on IPM in groundnut was organized on 24/9/1999 in which lectures, field visits, group discussions and question-answer sessions were arranged during the training programme for the benefit of farmers. A training manual on IPM in local language of Gujarati was prepared and distributed to 50 participating farmers.

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Dr. K. Chandran	National Seminar on Oilseeds and oils-Research and development needs in the millennium.	February2-4, 2000	DOR, Hyderabad
	Zonal workshop on NATP (Plant Biodiversity)	March 1-2, 2000	NBPGR(RS), Jodhpur
Dr. K.K. Pal	40th Annual Conference of AMI	January 22-24, 2000	Bhubaneshwar
	International Conference on Managing Natural Resources for Sustainable Agricultural Production in the 21st Century	February 14-18,2000	New Delhi
Dr. M.Y. Samdur	Breeding for resistance to biotic and abiotic stresses in crop plants	October 4 -29, 1999	TNAU, Coimbatore
	Monitoring breeder seed production plots from	September 15-25, 1999	Jaipur, Mainpuri, Kanpur, Hanumangar, and Ludhiana
	Rabi groundnut workshop	October 25- 27, 2000	TNAU, coimbatore
	National Seminar on Plant Physiology at interface of Agri-horticulture and Industry	December 31,1999-January 01, 2000	Rajasthan College of Agricultural, Udaipur (Rajasthan).
Dr. R. K. Mathur	The Analysis of Plant Breeding Multi-environmentTrials" at School of Land and Food and Mini-workshop of ACIAR-ICAR-ICRISAT collaborative project on "Breeding for high Water Use Efficiency in groundnut	May 24- June 18, 1999	University of Queensland, Brisbane (Australia) and J.B. Pillerson Research Institute of Agricultural Research, Kingaroy
	Krishi Mela	April 24-26, 1999	Siddsar
	Annual Rabi-summer groundnut workshop	November 22-31, 1999	TNAU, Coimbatore
	Seminar on "Groundnuts APEDA (Ministry of commerce, Government of India, New Delhi)	January 31, 2000	Rajkot
	Annual National Seed Porject (crops) Meeting	February 14-18, 2000	ARS, Durgapura, Jaipur
	Mahila Krishi Mela	February 19-21, 2000	Sardar bagh, Junagadh

TRAINING/VISITS

Participant	Seminar/training programme	Period	Place
Dr. S. Desai	Statistical Modelling of Biological Phenomena	May 10-19,1999	IARI, New Delhi
	National Seminar on Oilseeds and Oils - Research and Development needs for the Millennium	February 2-4, 2000	DOR Hyderabad, India
	Groundnut exporters meet	January 31, 2000.	Rajkot
	Integrated Pest Management, held at the Indian Institute of Chemical Research	October 8-9, 2000	Hyderabad, India.
Dr. Devidayal	1st International Conference on Micro and sprinkler irrigation systems	February 8-12, 2000	Jalgaon, Maharashtra
	International Conference on managing natural resources for Sustainable Agricultural production in the 21st Century	February 14-18, 2000	New Delhi
	group meeting on 'Strategies Issues for doubling the productivity of oilseed production systems by 2010	September 10-11, 1999	GAU, Junagadh
	Annual Kharif Groundnut Workshop	April 10-12, 2000	NRCG, Junagadh
	Short courses on "Crop Modeling"	January 20-30, 2000	CASS, IARI, New Delhi
Dr. P.C. Nautiyal	Training on Crop Simulation Modelling at Centre for Application of Systems Simulation	January 20 to 31, 2000	CASS, IARI, New Delhi
Dr. K. Rajgopal	Zonal workshop on NATP (Plant Biodiversity)	August 12, 1999	NBPGR (RS), Jodhpur
	1st consultation and orientation workshop on NATP (Plant Biodiversity)	August 24-25, 1999	NBPGR, New Delhi
	2nd National workshop on NATP (Plant Biodiversity)	March 23-24, 2000	NBPGR, New Delhi.
	AICRP(G) workshop summer	October 25-27, 1999	TNAU Coimbatore
	National Seminar on Oilseeds and oils-Research and development needs in the millennium	February 2-4, 2000	DOR, Hyderabad

Samdur, M.Y.; Mathur, R.K.; P. Manivel, H. K. Gor and B.M. Chikani. 2000. Screening groundnut genotypes for drought tolerance- a novel approach. Abstract in National Seminar on Plant Physiology at interface of Agri-horticulture and Industry from 31.12.1999 to 01.01.2000 at Rajasthan College of Agricultural, Udaipur (Rajasthan). pp.66.

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Popular Articles

Bandyopadhyay, A., P. K. Gosh, and R. K. Mathur.2000. Groundnut situation in India - the present scenario and future strategies.Indian farming 50(2): 13-20.

Ghosh, P.K.; Bandyopadhyay, A.; and Mathur, R.K. 1999. Management of groundnut in rice-based cropping system. Indian Farming. September, 1999, pp- 25-27.

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Ghewande, M.P. Nandgopal,V.and Mathur, R.K.1999.Integrated Pest Management in Groundnut.Farmers Training Manual under IVLP, September, 24, 1999, NRCG, Junagadh. PP-25.

Ghosh P.K, A. Bandyopadhyay, R.K. Mathur and P.C.Nautiyal. Technology for Rabi-Summer Groundnut - at a Glance. National Research Centre for Groundnut, Junagadh-362 001, Gujarat

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Rajgopal K. K. Chandran, H.B. Lalwani, P.K. Bhalodia and Sugadh Singh, Catalogue on groundnut germplasm (in press)

Rajgopal K., P. Manivel, A. Bandyopadhyay, K. Chandran H.B. Lalwani N.R.Ghetia and P.K. Bhalodia, Characterization of Released Groundnut Cultivars (in press)

QRT members on a field visit

QRT members in the Biotechnology lab

A phermore trap being explained to QRT

Annual Khariff workshop in progress

The following Research Associate//Senior Research Fellow has been appointed during the year April, 99 to March, 2000.

- Shri N.B. Bagwan, RA Joined on 19.11.99 under AP-NA Project
- Ms. Smitha Kumar, RA Joined on 11.11.99 under DBT Project
- Shri Deepak Kumar SRF Joined on 25.0599 under AP Cess Fund
- Shri Pradeep V. Fulmali SRF Joined on 25.5.99 under AP Cess fund
- Mrs. Sudha Desai, RA Joined on 7.1.2000 under ACAIR-ICAR CP Project
- Shri Uma Shankar Rajak, SRF Joined on 2.2.2000 under AP Cess fund
- Ms. Anju Mittal RA Joined on 30.3.2000 under DBT Project

Resigned

- The following Research Associate have been resigned from the post during the April, 99 to March, 2000.
- Miss Smitha Kumar, RA resigned on 1.3.2000
- Shri Deepak Kumar, SRF resigned on 19.11.1999

(B) Finance and Account

84% utilized of fund under Non-plan, 99% under Plan and 100% AICRP were ensured

Head	Plan		%	Non-plan		%
	Sanctioned	Utilized		Sanctioned	Utilized	
Estt. Charges including LPS & PF	15.75	15.53	0.98	150.00	126.55	0.84
T.A.	4.25	4.22	0.99	2.00	1.99	0.99
Other charges including equipment	102.04	102.80	100.00	14.00	11.25	0.80
Works	12.96	12.17	93.90	-	-	-
AICRP	135.00	135.00	100.00	-	-	-
Total	**270.00**	**269.72**	**99.98**	**166.00**	**139.79**	**84.21**

- Total number of 382 proposal were examined and audited during the financial year. A 1811 bills were audited and admitted for payment.
- 12 schemes /projects were successfully financed internally

Computerization

- An internally built computer package for GPF in Excel was developed for maintain GPF A/c of the staff.
- A GPF package in Access was designed and tested for operation. An account package for schemes was designed in access and tested for operation.

	Annual Group Meeting 'Breeding for high Water Use Efficiency in groundnut'	February 19- 23, 2000	Udaipur
Dr. P. Marivel	Groundnut Improvement Methodologies	October 14 - November 14, 1999	ICRISAT, Hyderabad
	Annual seed review meeting	March 12-14,1999	KAB, New Delhi
	National seminar on Oilseeds and oils-research development needs in the millennium	February 2-4, 2000	DOR, Hyderabad
Sh. G.C. Prasad	Brain Storming on Administrative Reform in ICAR	February, 2000	NAARM, Hyderabad
Sh. Rajeev Lal	Brain Storming on Administrative Reform in ICAR	February, 2000	NAARM, Hyderabad

Honours, Awards, recognitions etc.

Dr. S. Desai

Nominated as member of Editorial Board of Indian Phytopathology for a period of three years from 1999 to 2001.

Visiting Scientist in an ICRISAT-VUB Project on Biotechnology from February 2000 to April 2000 at International Crops Research Institute for Semi-Arid Tropics, Hydernbad and worked on Characterization of species of Trichoderma for their biocontrol ability against Aspergillus flavus using cultural, biochemical and molecular techniques.

OTHER INFORMATION

Administration and F & A section

Administration

Director NRCG has been assigned the responsibilities of coordination of the All India Coordinated Project on Groundnut.

Twelve residential quarters, 6 each in type III and type IV category were constructed and allotted to the employees. The NRCG residential complex now has a total of 37 quarters.

All the rusted iron poles here replace thery CPWD with the cemented ones which can will stand the storm and cyclonic winds prevalent in the area.

A contingent of 22 employees from NRCG participated in the ICAR Annual Sports Meet held in IISS, Bopal.

Total staff in NRCG, and the number of SC, ST and OBCs employed as on 31.03.2000

Category of staff	Sanctioned	Filled	Vacant	No of SC	No of ST	No of OBC
Scientific	41	23	18	5	-	-
Technical	45	43	02	9	3	5
Administrative	19	15	03	3	-	-
Supporting	21	20	01	5	-	10
Total	**126**	**101**	**24**	**22**	**3**	**15**

The following DPC/Assessment Committee Meetings were held at NRCG during the April, 99 to March, 2000:

- For fifteen technical personnel were assessed on 10.5.99 and 20.12.99. Ten of them were promotion to the next higher grade and 5 of them got the benefit of advance increment.
- DPC held on 28.02.2000 for considering the cases of promotion of Admn./Supporting staff under Assurance Career Promotion.
- RAC Meeting held at NRCG on 27.03.2000.

Transfer appointment

- Dr. P.K. Ghosh, got appointed as Senior Scientist and moned to IISS, Bhopal, w.e.f. 10.9.99.
- Dr. Y.V. Singh has appointed as Principal Scientist Agronomy and joined on 09.12.99.

PERSONNEL

NAME	DESIGNATION
Dr. A. Bandyopadhyay	Director
Mrs. Rosamma	PA to Director
Plant Genetic Resources	
Dr. K. Rajgopal	Scientist (SS)
Sh. K. Chandran	Scientist
Sh. H.B. Lalwani	Technical Officer (T-5)
Sh. P.K. Bhalodia	Technical Officer (T-5,on study leave)
Sh. Sugad Singh	T-II
Plant Breeding	
Dr. Radhakrishnan T.	Senior Scientist
Dr. R.K. Mathur	Scientist
Dr. M.Y. Samdur	Scientist
Dr. P. Manivel	Scientist
Sh. B.M. Chikani	Technical Officer (T-5)
Sh. M.A. Khan	Technical Officer (T-5)
Sh. H.K. Gor	Technical Officer (T-5)
Sh. J.R. Dobaria	T-4 (on study leave)
Genetics & Cytogenetics	
Dr. P. Paria	Senior Scientist
Sh.D.R. Bhatt	T-4
Sh.N. Pandya	T-1
Agronomy	
Dr. Y.V. Singh	Principal Scientist
Dr. Devi Dayal	Senior Scientist
Sh. P.R. Naik	Technical Officer (T-5)
Sh. Virendra Singh	Technical Officer (T-5)
Sh. D.M. Sachania	T-1
Plant Physiology	
Sh. Y.C. Joshi	Senior Scientist
Dr. P.C. Nautiyal	Scientist (SS)
Dr. A.L. Singh	Scientist (SS)

- Objection book was computerized for better monitoring to watch outstanding advances. The ARFIS for preparation of monthly account was continued.

TECHNICAL PROGRAMME

LIST OF RESEARCH PROJECTS AND SUB-PROJECTS AT THE NRCG AS APPROVED BY RAC HELD IN 1998, JUNAGADH, FOR THE YEARS 1998-2003

Programme I: Low-inputs, low risk efficient sustainable production packages for traditional rain-dependent areas

Project 01: Studies on crop improvement for resistance to biotic and abiotic stress

Project Leader: R.K. Mathur

Sub-project : Breeding and genetic studies on biotic stresses in groundnut

Sub-project : Breeding and genetic studies on abiotic stresses in groundnut

Project 02: IPM for groundnut based production cropping system

Project Leader: M.P. Ghewande

Sub-project : Integrated insect-pest management of thrips and defoliators in groundnut using non-synthetic pesticides, biocontrol, pheromone in CDR production system.

Sub-project : Integrated management of major diseases (ELS, LLS, rust, collar rot, stem rot) of groundnut.

Project 03: Management of post harvest problems in Groundnut

Project Leader : P.C. Nautiyal

Sub-project : Seed viability and dormancy

Sub-project : Storage pests

Project 04: Nutrient management in groundnut

Project Leader: K.K. Pal

Sub-project : Development of biofertilizer packages for groundnut

Sub-project : Mineral disorders of groundnut

Project 05: Studies on groundnut based cropping system

Project Leader: Devi Dayal

Sub-project : Studies on input management in intercropping system

Sub-project : Studies on sequential cropping system

Programme II: Cropping system for traditional rabi-summer and spring irrigated situations

Project 06: Cropping system for traditional rabi/summer and spring irrigated situations

Project Leader: Y.C. Joshi

Sub-project : Physiological studies on abiotic stresses

Sub-project : Development of cropping system

Programme III: Sustainable cropping systems for non-traditional areas with special emphasis on eastern and north-eastern parts of India.

Project 07: Development of suitable cropping system for non-traditional areas with special reference on eastern and north eastern parts of India

Project Leader: A.L. Singh

Sub-project : Studies on impact of agro-ecology and agr-economy

Sub-project : Development of suitable cropping system

Sub-project : Breeding to develop cultivars tolerant to Al toxicity

Sub-project : Organic farming

Programme IV: Understand and overcome the nature of barriers to enhance the genetic yield potential of cultivars by conventional and modern methods.

Project 08: Germplasm management of cultivated groundnut and its wild relatives.

Project Leader: K. Rajgopal

Sub-project : Collection, evaluation, documentation and distribution of cultivated groundnut and related *Arachis* species

Sub-project : *In vitro* conservation of groundnut germplasm

Sub-project : Enhancing the recombination frequency in groundnut

Project 09: Biotechnological approach to characterization and genetic enhancement of groundnut.

Project Leader: T. Radhakrishnan

Sub-project : Characterization, enhancement and molecular screening of *Arachis* gene pool

Sub-project : Developing and utilizing transformation protocols for groundnut to produce insect and virus resistant transgenics.

Programme V: Cropping system based on groundnut for diversified and value added products

Project 10: Assessment and enhancement of quality in groundnut and its value added products

Project Leader: J.B. Misra

Sub-project : Assessment of quality in germplasm collection, breeding material and produce of other experiments.

Sub-project : Breeding for HPS and confectionery cultivars

Sub-project : Genetic engineering for enhancement of quality

Sub-project : Microbial recycling of groundnut shell into useful products

Project 11: Prevention and management of aflatoxins and other mycotoxins in groundnut

Project Leader: S. Desai

LIST OF EXTERNALLY FUNDED PROJECTS AND CONTRACT RESEARCH

Sl. No.	Project Title	Funding Agency	Scientist handling	Duration From To	Nature of Project	Budget (Rs.in lakhs)
1)	Technology Assessment and Refinement through Instt. Village Linkage Programme	ICAR	Dr. M.P.Ghewande Dr. V. Nandagopal Dr. P.K. Ghosh Dr. R.K. Mathur Dr. K.S. Murthy	3 years (likely to be extended)	Research	35.00
2)	Identification and Evaluation of Biopesticides effective against the storage pest of groundnut bruchid beetle (Caryedon serratus) olivier	TMOP	Dr. K.K. Pal Dr. Rinku Dey	3 years (April'98 to March,2000)	Research	20.00
3)	Identification of efficiently nodulating and nitrogen fixing strains of Bradiryizobium and their application	DBT	Dr. K.K. Pal Dr. Rinku Dey Dr. P.K. Ghosh	Nov'98 to Oct,2001	Research	11.5
4)	Synthesis of sex pher-omone and develop-ment of pheromone trap for groundnut leaf miner	AP Cess fund ICT collabor-ation	Dr. V. Nandagopal Dr. J.S. Yadav et.al	March' 99 to Feb' 2002	Research	22.50
5)	Biovillage	DBT through CSIR	Dr. S.Desai Dr. K.K. Pal Dr. Devi Dayal	3 years	Research	0.00
6)	More efficient breeding for high water use efficiency peanut-in India and Australia	ACIAR	Dr. R.K. Mathur	4 years	Research	45.0

NAME	DESIGNATION
LIBRARY	
Sh. M.A. Khan	Technical Officer & IDO I/c
Sh. N.G. Vadher	Messenger
ARIS CELL	
Dr. Radhakrishnan T.	Incharge
Sh. N.R. Ghetia	Technial Officer(T-5)
FARM	
Dr. R.S. Tomar	Farm Superintendent
Sh. V.K. Sojitra	Technical Officer(T-5)
Sh. C.P. Singh	Technical Officer(T-5)
Sh. R.D. Padavi	Tech. Asstt. (T-II-3)
Sh. H.V. Patel	T-2
Sh. C.B. Patel	T-2
Sh. G.J. Solanki	T-2
Sh Prabhu Dayal	Tech Asstt. (T-II-3)
Sh. J.G. Kalaria	T Driver
Sh. P.M. Solanki	T. Driver
Sh. B.M. Solanki	
ADMINISTRATION	
Sh. Rajeev Lal	Administrative Officer
Sh. G.C. Prasad	Finance & Account Officer
Sh. J. Ramani	Assistatnt Admn. Officer
Sh. Balvir Singh	Security Supervisor
Sh. J.B.Bahtt	Assistant
Sh. R. Thakar	Assistant
Mrs. S. Venugopalan	Sr. Clerk
Mrs. M. N. Vaghasia	Sr. Clerk
Sh. P.B. Garchar	Electrician(T-II)
Sh. L.V. Tilwani	Jr. Stenographer
Sh. R.D. Nagvadia	Jr. Clerk
Sh. C.G. Makwana	Jr. Clerk
Sh. H.S. Mistry	Jr. Clerk

NAME	DESIGNATION
Sh. V.G. Koradia	Technical Officer (T-5)
Sh. P.V. Zala	Technical Officer (T-5)
Smt. Vidya Chaudhary	Technical Officer (T-5)
Microbiology	
Dr. K.K. Pal	Scientist
Dr. Rinku Dey	Scientist
Ku. Sheela Chauhan	Technical Officer (T-5)
Sh. D.M. Bhatt	Technical Officer (T-5)
Biochemistry	
Dr. J.B. Misra	Senior Scientist
Sh. R.S. Mathur	Tech. Officer (T-5)
Sh. V.K. Jain	Tech. Asstt. (T-II-3)
Sh. G.S. Mori	Lab cleaner
Entomology	
Dr. V. Nandagopal	Senior Scientist
Sh. M.V. Gedia	Tech. Asstt. (T-4)
Sh. A.D. Makwana	T-II
Plant Pathology	
Dr. M.P. Ghewande	Senior Scientist
Dr. S. Desai	Senior Scientist
Sh. H.M. Hingrajia	Technical Officer (T-5)
Sh. Premnarayan	Technical Officer (T-5)
Sh. S.D. Savalia	Tech. Officer (T-5, on Study leave)
AICRPG	
Dr. M.S. Basu	Project Coordinator (Till Feb., 2000)
Dr. A.L. Rathnakumar	Scientist
Dr. Chuni Lal	Scientist
Sh. D.L. Parmar	Technical Officer (T-5)
Sh. Ranvir Singh	Technical Officer (T-5)
Sh. K.A. Vasani	Assistant
Sh. Y.S. Karia	Jr. Stenographer
Sh. V.M. Chwada	Messenger

NAME	DESIGNATION
Sh. P.N. Solanki	DMO
Sh. K.H. Koradia	Driver
Sh. G.G. Bhalani	Driver
Sh. N.M. Safi	Messenger
Kum. D.C. Sachania	Messenger
Sh. B.I. Dabi	Safaiwala
Sh. B.K. Baria	Safaiwala
Sh. C.N. Jethwa	Watchman
Sh. R.B. Chawada	Watchman
Sh. R.V. Purohit	Watchman
Sh. R.P. Sondarwa	Watchman
Sh. G.J. Agrawat	Watchman
Sh. M.B. Sheikh	Watchman
Sh. V.N. Kodiater	Watchman
Sh. A.D. Makwana	Watchman
PHOTOGRAPHY	
Sh. A.M. Vakharia	Photogrpaher (T-II)
OSC, BHUBANESWAR	
Dr. S.K. Bera	Officer-in-charge
Sh. M.M. Dash	Technical Officer
Sh. Suraj Pal	Tech. Assst. (T-II-3)
Sh. Pitambar Dash	Field Assistant

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