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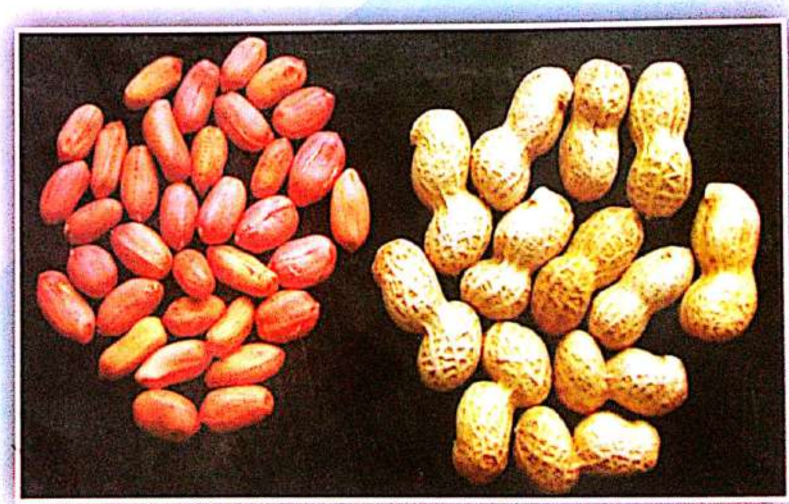
2006-07



राष्ट्रीय मूँगफली अनुसंधान केन्द्र

National Research Centre for Groundnut

(Indian Council of Agricultural Research)

P.B. No. 5, Ivnagar Road, Junagadh, Gujarat, India

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भाकृअनुप
ICAR

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NRCG CS line 281 : Crop in field (left) and Seed and pod Characteristics (right)

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PREFACE

Unlike the previous three years, the year 2006-07 has rather been not good for groundnut in India as there was a steep fall in production due to compounding effect of reduction in both area and productivity. This was due mainly to low and unevenly distributed rainfall in this year.

The closing of the year 2006-07 also coincided with the closing of the Xth Five Year Plan thus bringing about several tasks and activities to an abrupt halt which could not have been continued without receiving the approval of XIth Five Year Plan.

I take this opportunity to write this preface for the annual report of the National Research Centre for Groundnut for the year 2006-07 much against what the propriety would have otherwise demanded. Ideally speaking this report should have been published some time in May-June 2007 and this preface should have been written by the then incumbent director. I took over as the officiating director on 1st June 2008 and then as a regular director on 12th January 2009.

No sooner had I taken over than I realized that a huge back log of reports and other obligatory returns lay there to be disposed off. This backlog, among others included publication of annual reports for the years 2006-07 and 2007-08. While the unedited compilation of the annual report for the year 2006-07 was available, the report for the year 2007-08 was yet to be compiled and edited. By the time I was able to take grip of the situation, the report for the year 2008-09 also became due. I, therefore, started attempting to clear the back log first and then concentrate on the report for the year 2008-09. I was later, however, advised by my elders not to struggle with the previous annual reports and instead bring out the report for 2008-09 first. Heeding to this advice, I decided to go ahead first with the publication of the report for the year 2008-09. Although I could not have been held responsible for not bringing out the reports for the years 2006-07 and 2007-08, yet being guided by the proverbial wisdom 'its better late than never", I decided to clear the back log and maintain the continuity by publishing the missing links for the years 2006-07 and 2007-08. It was otherwise also desirable as publication of these reports will also bring on record the good research work that the scientists of NRCG have been doing during these years. Thus, with the publication of this report half the job of bridging the gap is over while the other half will be completed with the publication of report for the year 2007-08.

The contributions of all the scientists of NRCG for inclusion in this report are gratefully acknowledged. The efforts of Dr. Rinku Dey, Senior Scientist (Microbiology) in compiling, editing and overseeing the entire process of publication of this report are praise-worthy. The credit of providing Hindi version of the executive summary goes to Shri C.P. Singh, Technical Officer (T6) and Shri V.K. Jain Technical Officer (T-5).

J. B. Misra
Director

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- इस वर्ष के दौरान कुल 22 (4 स्पैनिश एवं 18 वर्जीनिया) अग्रिम प्रजननिक लाइनें विकसित की गई।
- जोन-* में ड्ढ के अन्तर्गत, चेक प्रजातियों से अधिक उपज देने वाली एक परीक्षण प्रविष्टि ट्ट 24030 को प्रजातीय पहचान समिति द्वारा विमोचन के लिए चिन्हित किया गया।
- तीन अग्रिम कल्चरों PBS 24004 एवं Jun 27 (वर्जीनिया बंच) तथा PBS 12160 (सैनिश बंच) को ICRP-G परीक्षणों के अन्तर्गत मूल्यांकित किया गया।
- विभिन्न प्रजननिक कार्यक्रमों के लिए बनाए गए 34 संकरों के पृथकीकृत पदार्थ को स्थान विशिष्ट के चयन एवं प्रजातियों के विकास के लिए मूंगफली पर अखिल भारतीय समन्वयित अनुसंधान परियोजना के 11 केन्द्रों पर भेजा गया।
- कीटों द्वारा कृत्रिम निष्पर्णन के एकप्रयोग में, यह पाया गया कि निष्पर्णन के बढ़ने के साथ-साथ उपज घटती जाती है और यदि सुइयां बनने तथा फलियां भरने के समय पौधे पर्णविहीन हो जांय तो उपज न्यूनतम होती है।
- कैरीडॉन सेरेटस (ब्रूचिड) के विरुद्ध परीक्षण की गई विभिन्न वनस्पतियों में शरीफा के बीजों के 1% चूर्ण से अण्डों की संख्या एवं फलियों के वजन में कमी न्यूनतम रही तथा लैन्टाना कैमारा की पत्तियों के 1% चूर्ण से वयस्कों की उत्पत्ति न्यूनतम पाई गई।
- कैरीडॉन सेरेटस (ब्रूचिड) प्रबन्धन हेतु विभिन्न प्रकार के थैलों के मूल्यांकन में उर्वरकों के बोरे सबसे उपयुक्त पाए गए।
- लोबिया तथा मूंगफली का अन्तर्शस्यन, जैसिड-संख्या कम करने में अनुकूल पाया गया। ज्वार तथा मक्का के साथ मूंगफली के अन्तर्शस्यन से थ्रिप्स की संख्या बढ़ी जब कि अरहर से यह संख्या कम हुई। पुनश्च: अरण्डी के साथ मूंगफली के अन्तर्शस्यन ने सबसे अधिक लागत-लाभ अनुपात (CBR-1:1.95) दिया और उसके बाद अरहर ने।
- NRCG CS 101, 109, 243 एवं 272 जीनप्ररूपों को जैसिड के प्रति मध्यम दर्जे का प्रतिरोधक पाया गाया तथा मूंगफली की AK 159, VRI 2-1 एवं VRI 4 प्रजातियों को थ्रिप्स के प्रति मध्यम दर्जे का प्रतिरोधक पाया गाया।
- खेतों में बीयुवेरिया बैसिआना (*Beauveria bassiana*) के 2 ग्रा./ली. के अनुप्रयोग द्वारा जैसिड़ पर तथा वी. लैकिनी *(V. lecanii)* के 2 ग्रा./ली. के अनुप्रयोग द्वारा थ्रिप्स पर प्रभावी नियन्त्रण पाया गया।
- चूसने वाले कीटों के लिए ट्रैपिंग पदार्थ के रूप में पानी की तुलना में अरण्डी का तेल बेहतर पाया गया। एफिड एवं जैसिड को ट्रैप करने के लिए पीला रंग अत्यन्त दक्ष पाया गया।
- नवम्बर, दिसम्बर, जनवरी एवं फरवरी की अवधि में एफिड तथा फरवरी एवं मार्च में जैसिड की संख्या अधिकतम पाई गई जब कि नवम्बर से मार्च की अवधि में पर्णसुरंगियों की प्रचुर संख्या अवलोकित की गई।
- खरीफ 2006 में आठ जीनप्ररूपों यथा: NRCG CS nos. 30, 154, 264, 268, 285, 303, 311 एवं 329 ने अगेती एवं पछेती झुलसा (रोग की तीव्रता कमोवेश 2.0) के प्रति आशाजनक प्रतिरोधकता दर्शाई।
- मूंगफली में कलिका क्षयन रोग के प्रति सुग्राही प्रजाति GG 2 में अधिकतम 18.33% प्रकोप की तुलना में 16 जीनप्ररूपों में कोई प्रकोप नहीं पाया गाया।

कृत्रिम परिस्थितियों में NRCG CS 19 ने स्क्लेरोशियम रोल्फसी *(Sclerotium rolfsii)* के प्रति प्रतिरोधकता दर्शाई।

- इन–विट्रो परिस्थितियों (बीजों में 30% से कम उपनिवेशन) में GG 2 (83.3%) एवं कुछ अन्य जीनप्ररूपों (100%) की तुलना में CS 168 एवं CS 25 ने एसपर्जिलस नाएजर के प्रति मध्यम दर्जे की प्रतिरोधकता दर्शाई।
- ट्राइकोडर्मा के दो आइसोलेटों यथा: NRCG T 06 *(T. virens)* एवं NRCG T 17 *(T. harzianum)* को इन–विट्रो परिस्थितियों में एसपर्जिलस नाएजर (कंठ–सड़न) एवं स्क्लेरोशियम रोल्फसी (तना–सडन) के अत्यन्त विरुद्ध पाया गया तथा कृत्रिम प्रवेशन की परिस्थितियों में इन रोगों के नियंत्रण में प्रभावी पाया गया।
- उच्च जल–उपयोग दक्षता वाली लाइनों की पहचान की गई तथा उन्हें FPRE अभिगम के द्वारा वर्षा पर आधारित प्रणाली के अन्तर्गत चयनित किया गया।
- सूखा एवं सूखा से प्रेरित उच्च तापक्रम सहनशीलता से सम्बद्ध विभिन्न गुणों की पहचान के लिए एरैचिस की जंगली जातियों और उनकी प्रविष्टियों का लक्षण निश्चयन किया गया।
- अंकुरण तथा पौधों की आरम्भिक अवस्था के दरम्यान लवणता के प्रति सहनशीलता के लिए मूंगफली के 72 किस्मों का मूल्यांकन किया गया और सहनशील एवं सुग्राही किस्मों की पहचान की गई।
- वर्षा–आधारित प्रणाली में खेती के उपयुक्त एक इडियोटाइप *(ideotype)* प्रस्तावित करने हेतु मूल एवं तना की वृद्धि, फसल के वितान या छतरी की शिल्प तथा बीज एवं नवजात पौधों के ओज पर ध्यान केन्द्रित करते हुए इडियोटाइप की अवधारणा पर कार्य प्रारम्भ किया गया।
- मूंगफली की प्रजातियों GG 2 एवं JL 24 के साथ खेतों में परीक्षण में non-fluorecsent pseudomonads के एक कन्सोर्शियम (consortium) के प्रवेशन के परिणामस्वरूप पौधों की वृद्धि से सम्बन्धित गुणों तथा फलियों की उपज में विकास हुआ।
- मूंगफली के बड़े बीजों वाली प्रजातियों में PGPR कल्चर को बीजों में प्रवेशक के रूप में अनुप्रयोग के परिणामस्वरूप वृद्धि, उपज एवं पोषक तत्वों को अवशोषण में विकास हुआ।
- PGPR, PSM एवं rhizobia के कन्सोर्शिया का मूल्यांकन किया गया और PSM एवं rhizobia के एक कन्सोर्शियम को मूंगफली (GG 2) के फली उत्पादन में बढ़ोत्तरी करने में आशाजनक पाया गया। PGPR कल्चरों के प्रवेशन स सिंचित परिस्थितियों में ग्रीष्म कालीन मूंगफली (TG 26) में वृद्धि तथा उपज के पैमानों का विकास हुआ।
- मूंगफली के छोटे दानों वाले जीनप्ररूपों की अपेक्षा बड़े दानों वाले जीनप्ररूपों को फॉस्फोरस की अधिक आवश्यकता होती है तथा इनके दानों एवं छिलकों में अधिक फॉस्फोरस पाया जाता है। कैल्शियम के अनुप्रयोग से दानों एवं छिलकः में कैल्शियम की मात्रा बढ़ती है और यह अनुप्रयोग बड़े दानों वाले जीनप्ररूपों में अधिक प्रभावी पाया गया है। मूंगफली के बडे. दानों वाले जननद्रव्यों में जिंक की कमी के लक्षण पाए गए जिससे संकेत मिला कि इनमें जिंक की उचित मात्रा की पूर्ति नहीं की जा रही है।
- मूंगफली में फॉस्फोरस एवं कैल्शियम के अनुप्रयोग से फलियों एवं दानों की लम्बाई तथा चौडाई बढ़ती है और फली उत्पादन बढ़ता है।

- खेत में 103 जीनप्ररूपों की छंटनी से कुछ पोटाश–दक्ष एवं गन्धक–दक्ष जननद्रव्यों की पहचान की गई। जिनमें पोटाश–दक्ष जीनप्ररूपों में LGN 2, ICGV 88448, Tirupati 3, TKG 19A, ICGV 86590, NRCG 1308, ICGS 76, CSMG 884, M 335, NRCG 7085-1 तथा गन्धक–दक्ष जीनप्ररूपों में ICGV 86590, LGN 2, M 335, TG 64, FeESG 10-1, CSMG 884, B 95, Somnath, BAU 19, एवं TKG 19A प्रमुख हैं।
- चार स्थानों से प्राप्त आंकड़ों के आधार पर कुछ पोषक–तत्व–दक्ष लाइनों की पहचान की गई जिनमें फॉस्फोरस–दक्ष लाइनों में ICGV 86590, FeESG 8, CSMG 84-1, SG 84, ICGS 76 तथा कैल्शियम–दक्ष लाइनों में CSMG 84-1, M 335, ICGV 86590, DSG 1, GG 7 एवं GG 13 प्रमुख हैं।
- मूंगफली के 70 जननद्रव्यों के बीजों में जस्ते की मात्रा के लिए विश्लेषण किया गया तथा उन्हें कम (30 मि.ग्रा./कि.ग्रा.), मध्यम (31–50 मि.ग्रा./कि.ग्रा.) तथा उच्च (कमोवेश 51 मि.ग्रा./कि.ग्रा.) श्रेणी में वर्गीकृत किया गया।
- मूंगफली–गेहूं–मूंग की सघन शस्य प्रणाली (200–300%) के अन्तर्गत, मूंगफली की समतुल्य उपज तथा कुल उत्पादकता के साथ–साथ मृदा में नत्रजन एवं कार्बनिक पदार्थ की अधिकतम मात्रा दर्ज की गई।
- मूंगफली में 0.80 PE पर 9 सिचाइयां करने तथा वानस्पतिक अवस्था पर अल्पकालिक सूखे का दबाव देने पर फलियों का अधिकतम उत्पादन दर्ज किया गया।
- पानी की सीमित उपलब्धता के अन्तर्गत मूंगफली की वानस्पतिक एवं फलियों के पकने की अवस्था (90–100 दिन) में सिंचाई को टाल देने तथा 7.76–7.81 कि.ग्रा./मि.मी./ है. की जल उत्पादकता में 0.80 PE पर 7 सिचाइयां करने से भी मूंगफली की फसल का प्रबन्धन किया जा सकता है।
- कैल्शियम एवं पोटैशियम के अनुप्रयोग से जल–उपयोग–दक्षता बढती है जो कि प्रक्षेत्र–क्षमता की 60% कमी पर अधिकतम पाई गई। सिंचित मूंगफली में अच्छी उपज तथा जल उत्पादकता पाने के लिए कैल्शियम एवं पोटैशियम का अनुपात एक महत्वपूर्ण कारक प्रतीत हुआ है।
- मानसून से पूर्व सूखे की स्थिति में मूंगफली की बुआई के लिए कैल्शियम सल्फेट एवं गाय के गोबर से बीजों के विलेपन ने कुछ सामर्थ्यता दर्शाई।
- मूंगफली+कपास की अन्तर्शयन प्रणाली के लिए मूंगफली की प्रजाति GG 20 को अत्यन्त सुसंगत पाया गया तथा अधिकतम फली उत्पादन पाया गया।
- मूंगफली–राई के फसल चक्र में दो साल (2005–06 तथा 2006–07) तक लवणीय जल (0.5 से 6.0 dS/m) का उपयोग किया गया। परिणामों ने दर्शाया कि काली लवणीय चिकनी मिट्टी में मूंगफली एवं राई की ईष्टतम उपज के लिए सिंचाई–जल की लवणता की दहलीज क्रमश: 2–3 dS/m तथा 4–6 dS/m है।
- सिंचाई के जल तथा मृदा में उच्च लवणता के कारण मूंगफली और राई में तेल एवं नत्रजन (प्रोटीन) की मात्रा में कमी पाई गई।
- विमोचित प्रजातियों का लवणीय मृदा में परीक्षण करने पर वर्जीनिया वर्ग में GG 20 तथा स्पैनिश वर्ग में TG 26, TAG 24 एवं ICGS 37 ने अधिकतम उत्पादन दिया। स्पैनिश प्रजातियों की तुलना में वर्जीनिया प्रजातियों ने लवणता के प्रति अपेक्षाकृत अधिक सहनशीलता दर्शाई।

- पूर्वोत्तर पर्वतीय क्षेत्रों में उच्च उत्पादकता के लिए TKG 19A, GG 20, ICGS 76, CSMG84-1, ICGV 86590 तथा M 13 प्रजातियों की पहचान की गई तथा NRCG 1308, 7206, 7471, FeESG 10-1, FeESG 10-3 एवं ICGV 88448 जीनप्ररूपों को फली और दानों की उच्च उत्पादकता (फलियां-1500 एवं दाने 1000 कि.ग्रा./है.) के साथ-साथ पोषक तत्व दक्ष पाया गया।
- मूंगफली+मक्का के अन्तर्शस्यन में मूंगफली का अधिकतम (1776 कि.ग्रा./ है.) उत्पादन पाया गया। पूर्वोत्तर पर्वतीय क्षेत्रों में बड़े बीजाकार वाली मूंगफली की प्रजातियों ICGS 76 तथा GG 20 ने अच्छा प्रदर्शन किया।
- गोबर की कम्पोस्ट-10 टन, सरसों की खली-1 टन, ग्लिरिसिडिया की हरी पत्तियाँ-10 टन तथा वर्मीकम्पोस्ट-2 टन प्रति हैक्टर को सार्थक अवशिष्ट प्रभाव के साथ-साथ सबसे अधिक आशाजनक कार्बनिक स्रोतों के रूप में पाया गया। पूर्वोत्तर पर्वतीय क्षेत्रों में बोरॉन की भूमिका की भी दर्ज किया गया। फॉस्फोरस (50 कि.ग्रा.)+ पोटाश (100 कि.ग्रा.)+ चूना (2.5 टन)+FYM (10 टन) प्रति है. के अनुप्रयोग ने अधिकतम फली उत्पादन (2017 कि.ग्रा./है.) दर्शाया।
- पांच अनुभागों का प्रतिनिधित्व करने वाली छियान्बे प्रविष्टियों- Procumbents (06), Erectoides (04), Arachis (49), Hecteranthae (02) mnà Rhizomatosae (35), को खेत के जीन बैंक में अनुरक्षित किया गया। 9023 प्रविष्टियों को मध्यम अवधि के शीत भंडार (4° तापक्रम एवं 30% आपेक्षिक आर्द्रता पर) में संरक्षित किया गया।
- इकत्तीस नई प्रविष्टियों, जिनमें 9 जंगली एरैचिस की सम्मिलित हैं, को स्थानीय अन्वेषण के द्वारा तथा NBPGR के रांची केन्द्र स एकत्रित किया गया। फसलोन्नत कार्यक्रमों हेतु 24 मांगकर्ताओं, यथा: NRCG (346), ICAR के संस्थानों (11) तथा विभिन्न विश्वविद्यालयों (955), को कुल 1312 प्रविष्टियों की आपूर्ति की गई। कुल 322 प्रविष्टियों का पर्याप्त मात्रा में बहुगणन किया गया तथा उन्हें लम्बी अवधि के संरक्षण हेतु NBPGR में जमा किया।
- मूंगफली की 184 प्रविष्टियों के एक लघु मुख्य वर्ग (mini-core collection) का 19 गुणात्मक एवं 27 मात्रात्मक लक्षणों के लिए एन आर सी जी, जूनागढ तथा एम पी के वी, जलगांव में परिलक्षणन किया गया। दोनों ही स्थानों पर फली उत्पादन (ग्रा./पौधा एवं वर्ग मीटर), फली की लम्बाई तथा 100-दानों-का-भार में coefficient of variability (CV %) अधिक दर्ज की गई जब कि जूनागढ की परिस्थितियों के अन्तर्गत लिए गए अवलोकनों की अपेक्षा जलगांव में दाने की लम्बाई तथा चौडाई अधिक होने के कारण अवलोकनों में भिन्नता पाई गई।
- मूंगफली की 120 वोमोचित प्रजातियों का 19 गुणात्मक एवं 27 मात्रात्मक लक्षणों के लिए परिलक्षणन किया गया। DUS के मार्ग निर्देशन के आधार पर भी प्रजातियों का परिलक्षणन किया गया तथा इनमें से प्रत्यक प्रजाति के लिए कुछ विशिष्ट आकारकीय गुणों की पहचान की गई।
- J 11x *A. rigonii* के अलावा सभी संकर संयोगों में सही संकर (true hybrids) पाए गए।
- F1 तथा F2 पीढ़ियों के लक्षण प्ररूप अनुपात से स्पष्ट हुआ कि 'सिकुड़ी-पत्ती' एवं 'सफेद-बीजचोल' बनाम (v/s) 'सिकुड़ी-पत्ती' एवं 'लाल-बीजचोल' स्वतन्त्र रूप से पृथकीकृत होते हैं तथा एकजीनी/एकलिंगी प्रवृत्ति के होते हैं।
- गमलों में लवणता के विरुद्ध 150 अग्रिम प्रजननिक लाइनों की छंटनी की गई।
- आणविक सूचकों के आधार पर एरैचिस की जंगली प्रजातियों की उपलब्ध प्रविष्टियों में संबन्ध का आंकलन किया गया।
- 30 SSR प्राइमरों का उपयोग करके पॉलीमार्फिज्म के लिए GG 20, NRCG CS 19, ICGV 86590, PBS 24030 एवं GPBD 4 जीनप्ररूपों तथा NRCG CS19 के साथ उनके संकरों का विश्लेषण किया गया।

- पच्चीस प्रतिशत से अधिक प्रोटीन वाले 16 किस्मों की पहचान की गई।
- पचास प्रतिशत से अधिक तेल वाले 14 जीनप्ररूपों की पहचान की गई। मूंगफली के मुख्य प्ररूप संग्रह (126 जीनप्ररूपों) के बीजों में तेल की औसत मात्रा 45.4% (40.6 से 50.8%) पाई गई जब कि प्रोटीन की औसत मात्रा 25.1% (18.2 से 29.8%) पाई गई।
- मूंगफली के विकसित हो रहे दानों में विटामिन–सी की अच्छी मात्रा (1–3 मि.ग्रा./100ग्रा.) पाई गई जो कि फलियों के पकने के साथ–साथ क्रमश: कम होती जाती है।
- उन्नीस किस्मों में एलर्जेन की मात्रा के जीनप्ररूपी अन्तर को स्पष्ट पाया गया।
- गेहूं एवं मूंगफली के मिश्रित (80:20) आटे से बनी चपाती में स्वाद के दृष्टिकोण से उत्तम समायोजन पाया गया।
- एक नए पकवान 'मूंगफली की चाट' को स्वीकार्य पाया गया।
- तीन सूक्ष्मजीवों यथा: *Bacillus amyloliquefaciens* (एमाइलेज उत्पादक) एवं *Bacillus sp.* तथा *Aspergillus oryzae* (दोनों प्रोटीएज उत्पादक) को जब मूंगफली की तेल–रहित खली पर संवर्धित किया गया तो अन्य एन्जाइम भी उत्पादित हुए। *B. amyloliquefaciens* के अर्क में सेल्युलेज एवं प्रोटिएज पाए गए जब कि *Bacillus sp.* तथा *A. oryzae* में सेल्युलेज एवं एमाइलेज पाए गए। $4^{\circ}C$ तापक्रम पर भंडारण पर दो मास की अवधि में *B. amyloliquefaciens* द्वारा उत्पादित एमाइलेज ने अपनी 50% सक्रियता खो दी।
- पराबैंगनी उत्प्रेरण द्वारा *Bacillus subtilis* P5 के प्रोटिएज उत्पादन के सामर्थ्य को सफलतापूर्वक बढ़ाया गया।
- एन आर सी जी पर *Aspergillus* की एक रिपोजिटरी विकसित की गई जिसमें *Aspergillus sp.* (अधिकतर *Aspergillus flavus* तथा *Aspergillus ochraceus)* के 417 आईसोलेट्स हैं। इस रिपोजिटरी को agar slants पर एकल बीजाणु संवर्ध तथा दीर्घकालीन भंडारण के लिए lyophilized संवर्ध के रूप में अनुरक्षित किया जा रहा है।
- ट्राइकोडर्मा के 4 आईसोलेटों यथा NRCG T12, NRCG T16, NRCG T32, और NRCG T34 को एस्पर्जिलस फ्लैवस के प्रति अत्यधिक अवरोधक (वृद्धि में45 % रुकावट) पाया गया ये 5 दिनों में ही रोगजनकों पर पूर्ण रूप से छा जाते हैं।
- माइक्रोबियल AFLP (invitrogen) के लिए व्यवसायिक किट का उपयोग करके एस्पर्जिलस फ्लैवस के AFLP के लिए एक प्रोटोकोल का मानकीकरण किया गया।
- कायिक संरचना में समानता लेकिन विषाक्तता में भिन्नता के साथ एस्पर्जिलस फ्लैवस के 16 आईसोलेटों में DNA polymorphism का पता लगाया गया।
- सन् 2000 की विभिन्न ऋतुओं में मूंगफली की 20 उन्नत प्रजनक लाइनों/जीनप्ररूपों ने एस्पर्जिलस फ्लैवस के संक्रमण और उसके बाद एफ्लाटॉक्सिन संदूषण के प्रति सहिष्णुता दर्शायी।
- विभिन्न ऋतुओं में फसल–कटाई से पूर्व एकीकृत एफ्लाटॉक्सिन प्रबंधन पैकेज का मूल्यांकन किया गया और एफ्लाटॉक्सिन संदूषण को रोकने में इसे सार्थक रूप से महत्वपूर्ण पाया गया।
- जूनागढ़ जिले में मूंगफली के किसानों की सामाजिक–आर्थिक स्थिति मध्यम से उच्च पायी गयी।

किसानों में GG20, GG2, GAUG10 और Punjab1 बहुत ही लोकप्रिय प्रजातियां हैं।

- ईष्टतम पोषक तत्व (एन. पी. के. और सूक्ष्म– पोषक तत्व) प्रबंधन पद्धतियों की ग्राह्यता और जैविक खादों का अनुप्रयोग बहुत ही कम पाया गया।
- मूंगफली की बीमारियों में तना और कंठ–सड़न मुख्य पायी गयीं। किसान ऐसी प्रजाति पसन्द करते हैं जो कि GG20 के समान हो परन्तु तना–सड़न के प्रति प्रतिरोधी हो।
- ज्यादातर किसानों को मूंगफली में एफ्लाटॉक्सिन संदूषण संबंधी जानकारी नहीं है।
- 'बड़े बीज–आकार' गुण को समाहित करने के लिए नये संकर बनाए गये। F5 और F6 पीढियों में 37 समलक्षणी चयन किये गये।
- बीज–आकार को बढ़ाने के लिए बनाए गए दस संकरों के F3 पीढ़ी के पृथकीकृत पदार्थ को अखिल भारतीय मूंगफली अनुसंधान समन्वयित परियोजना (AICRPG) के 8 केंद्रों पर भेजा गया।
- बड़े–बीज आकार की अग्रिम प्रजनन लाइन PBS 29080 को अखिल भारतीय मूंगफली अनुसंधान समन्वयित परियोजना के अंतर्गत परीक्षण में आंकने के लिए प्रस्तावित किया गया। खरीफ 2006 में अग्रिम प्रजनन लाइन ICGV 99101 को AICRP(G) के LSVT के तहत मूल्यांकित किया गया।
- प्रयोगशाला में छंटनी किए गए जीनप्ररूपों ICGV 89214, ICGV 97061, ICGV 99101, PBS 29035, PBS 29078, ICGV 9705:, PBS 29047, PBS 29079 A, PBS 29073 तथा PBS 29069 ने एसपर्जिलस फ्लैवस (आइसोलेट AF 111) के द्वारा बीज उपनिवेशन में कोई मदद नहीं की।
- मौसम के दरम्यान जूनागढ में कम व अधिक क्षमता वाली चिक्की उद्योग से क्रमश: 3225 तथा 4200 घंटे प्रति माह रोजगार पैदा होता है जबकि बे–मौसम में मात्र 960 एवं 740 घंटे प्रति माह ही रोजगार उपलब्ध हो पाता है। नमकीन मूंगफली के उद्योग में भी इसी प्रकार का झुकाव प्राप्त हुआ है।
- चिक्की तथा नमकीन मूंगफली के उद्योग में उत्पादन की मुख्य लागत में भिन्नता पाई गई, खासतौर पर मुख्य कच्चे पदार्थ जैसे कि मूगफली के दाने में।
- पन्द्रह पारगामी संकर तथा 5 नए अन्तर्जातीय संकर बनाने का प्रयास किया गया।
- उन्नासी एकल पौधों तथा 83 अन्तर्जातीय संततियों के ढेरों को अगली पीढी के लिए बढाया गया।
- दाने के रंग के लिए दो आइसोजनिक उत्परिवर्ती लाइनों ('सिकुडी पत्ती–लाल बीजचोल' एवं 'सिकुडी पत्ती–सफेद बीजचोल') तथा तीन बड़े बीज वाली अगेती स्पैनिश जीनप्ररूपों (NRCG CS 148, 268 एवं 281) को विकसित किया गया।
- मूंगफली के कलिकाक्षयन रोग के विरुद्ध एक आशाजनक प्रतिरोधकता वाले जीनप्ररूप NRCG CS 85 को विकसित किया गया।
- *A. prostrata* में leaf callogenesis को प्रेरित करने में NAA एवं 2,4-D के संमिश्रण की अपेक्षा मात्र picloram अधिक प्रभावी पाया गया है। *A. prostrata* में leaf callogenesis को प्रेरित करने में NAA एवं 2,4-D की अपेक्षा BPA या thidiazuron (TDZ) के साथ picloram का संमिश्रण अधिक उत्तरदायी पाया गया है।

Executive Summary

- Forty-five fresh crosses were attempted in *kharif* 2006 to incorporate resistance to different biotic and abiotic stresses into agronomically superior genotypes.
- A total of 22 new advanced-breeding lines, 4 Spanish and 18 Virginia, were developed during the year.
- A test entry, PBS 24030 which out yielded the check varieties under AVT in Zone I was identified for release by the Varietal Identification Committee.
- Three advanced cultures, PBS 24004 (Virginia bunch), PBS 12160 (Spanish bunch) and JUN 27 (Virginia bunch) were evaluated under AICRP-G trials.
- Segregating materials of 34 crosses attempted for different breeding objectives were supplied to 11 AICRP-G centers for location specific selection and varietal development.
- In insect simulated artificial defoliation experiments, pod yield decreased with increasing defoliation, and when the plants were defoliated during pegging and pod filling stages the pod yield was the lowest.
- Among different botanicals tested against *Caryedon serratus*, oviposition and pod weight loss was minimum in 1% custard apple seed powder and the adult emergence was minimum in 1% *Lantana camara* leaf powder.
- Among different receptacles evaluated for the management of *Caryedon serratus*, fertilizer bags were found most suitable.
- The cowpea-groundnut intercrop was found suitable for reducing the jassid population. The sorghum and maize intercrops increased the thrips population while pigeon pea reduced it. The intercropping with castor, however, gave the highest CBR (1:1.95) followed by pigeon pea (1:1.86).
- The genotypes NRCG CS nos. 101, 109, 243 and 272 were found to be moderately resistant to jassids, and the varieties AK 159, OG 52-1 and VRI 4 were moderately resistant to thrips.
- Effective control under field conditions could be obtained through application of *Beauveria bassiana* @ 2g/L for jassids and *Verticillium lecanii* @ 2g/L for thrips.
- Compared to water, castor oil was found superior as trapping material for sucking pests. The yellow colour was found quite efficient in trapping aphids and jassids.
- The aphid population was high during November, December, January and February; Jassids were abundant during February and March and a surge in population of leaf miners was observed during November to January.
- Eight genotypes *viz.*, NRCG CS nos. 30, 154, 264, 268, 285, 303, 311 and 329 showed promising resistance to ELS and LLS (disease severity 2.0) during *kharif* 2006.
- Compared to the highest incidence of 18.33% of PBND in susceptible check GG 2, in sixteen genotypes there was no incidence.
- NRCG CS 19 showed resistance to *Sclerotuim rolfsii* (stem rot) under artificial conditions.
- CS 168 and CS 25 showed moderate level of resistance to *Aspergillus niger* under *in-vitro* conditions (>30% seed colonization) compared to GG2 (83.3%) and some other genotypes (100%).
- Two isolates of *Trichoderma viz.*, NRCG T 06 (*T. virens*) and NRCG T 17 (*T. harzianum*), were found to be highly antagonistic to both *A. niger* (collar rot) and *S. rolfsii* (stem rot) under *in vitro* conditions and effectively controlled the diseases under artificially inoculated conditions.
- High water-use-efficient lines were identified and selected for on farm trials under rain-dependent system in FPRE approach.

- Wild *Arachis* species and their accessions were characterized to identify various traits associated with drought and drought induced high temperature tolerance.
- Twenty-seven groundnut cultivars were evaluated for tolerance of salinity during germination and early seedling stage and then tolerant and susceptible cultivars were identified.
- Work on ideotype concept began with a focus on root and shoot growth, crop canopy architecture, and seed and seedling vigour to propose an *"Ideotype"* suitable for the cultivation in rain-dependent system.
- Inoculation of a consortium of non-fluorescent pseudomonads resulted in improved plant growth characteristics and pod yield in field trials with groundnut cultivars GG 2 and JL 24.
- Application of PGPR cultures as seed inoculants resulted in improved growth, yield and nutrient up take of bold-seeded groundnut cultivars.
- Consortia of PGPR, PSM and rhizobia were evaluated and a consortium of PSM and rhizobia was found promising for enhancing pod yield of groundnut (GG 2). Inoculation of PGPR cultures improved the growth and yield parameters of summer groundnut (TG 26) under irrigated conditions.
- The large-seeded genotypes required more P and showed higher P in their kernels and shell than the small seeded genotypes. Calcium application increased Ca content in seed and shell with a more pronounced effect on large seeded genotypes. The large seeded groundnut genotypes were also found to show Zn deficiency indicating that their Zn requirement was not met properly.
- Application of P and Ca, increased pod yield by increasing the length and width of the pod and seed in groundnut.
- A number of K- and S-efficient genotypes were identified by screening 103 genotypes in the field. K-efficient genotypes were: LGN 2, ICGV 88448, Tirupati 3, TKG 19 A, ICGV 86590, NRCG 1308, ICGS 76, CSMG 884, M 335, NRCG 7085-1; and S-efficient genotypes were: ICGV 86590, LGN 2, M 335, TG 64, FeESG 10-1, CSMG 884, B 95, Somnath, BAU 19, and TKG 19 A.
- On the basis of data obtained from four locations, some nutrient efficient lines were identified. P-efficient: ICGV 86590, FeESG 8, CSMG 84-1, SG 84, ICGS 76; and Ca-efficient: CSMG 84-1, M 335, ICGV 86590, DSG 1, GG 7, GG 13.
- The seeds of 70 groundnut genotypes were analyzed for Zn for categorizing these as low (below 30 mg/kg), medium (31-50 mg/kg) and high ($\geq$ 51 mg/kg Zn) zinc density genotypes.
- Under intensive cropping system (200-300%), groundnut-wheat-greengram system recorded maximum groundnut equivalent yield, total productivity, and also total soil nitrogen and soil organic carbon.
- Application of nine irrigations at 0.80 PE and providing a transient stress at vegetative stage in groundnut recorded highest pod yield.
- Under limited water availability, irrigation to groundnut can be managed with seven irrigations at 0.80 PE, skipping irrigation at vegetative and pod maturity stages (90-100 days) and a water productivity of 7.76-7.81 kg/mm/ha.
- Application of Ca and K improved the WUE which was the maximum under 60% deficit of field capacity. The Ratio of Ca and K appeared to be an important factor for achieving improved yield and water productivity in irrigated groundnut.
- Seed coating with $CaSO_4$ and cow dung showed some potential for sowing of groundnut under dry conditions (pre-monsoon).
- For groundnut + cotton intercropping system, groundnut variety GG 20 was very compatible and gave the highest pod yield.

- Saline water (0.5 to 6 dS/m) was used in groundnut-mustard rotation for two years (2005-06 and 2006-07). The results showed that in saline black clay soil 2-3 dS/m and 4-6 dS/m salinity of irrigation water were the threshold salinities for optimum yield of groundnut and mustard crops, respectively
- Oil content and nitrogen (protein) content in groundnut and mustard crops decreased significantly due to high soil and irrigation water salinities.
- Among the released varieties tested in saline soil, GG 20 and ICGS 37 gave the maximum yield under Virginia group and TG 26, TAG 24 and ICGS 37 gave the maximum yield in Spanish group. Virginia varieties showed relatively high tolerance to salinity than Spanish varieties.
- Cultivars TKG 19A, GG 20, ICGS 76, CSMG 84-1, ICGV 86590 and M 13 were identified to be high yielding for NEH region and genotypes NRCG 1308, 7206, 7471, FeESG 10-1, FeESG 10-3 and ICGV 88448 to be high yielding and also nutrient efficient with pod yield more than1500 kg/ha and kernel yield more than1000 kg/ha.
- The maximum groundnut yield was obtained in maize + groundnut intercropping (1766 kg/ha).The large seeded groundnut cultivars, ICGS 76 and GG 20 performed well in NEH region
- Cow dung compost (10 t/ha), mustard oil cake (1 t/ha), *Gliricidia* green leaf (10 t/ha) and vermicompost (2 t/ha), were the most promising organic sources with significant residual effect. The role of B was also noticed in NEH region. Application of 50 kg P_2O_5/ha + 100 kg K_2O/ha + Lime 2.5 t/ha + FYM (10 t/ha) showed maximum pod yield of 2017 kg/ha.
- Ninety-six accessions representing five sections: Procumbentes (06), Erectoides (04), Arachis (49), Heteranthae (02) and Rhizomatosae (35) were maintained under field gene bank. Nine thousand twenty-three accessions were conserved for the medium-term in cold store (temperature 4°C and RH 30%).
- Thirty-one new accessions including nine wild *Arachis* species were assembled through local exploration and from NBPGR, Ranchi station, respectively. A total of 1362 accessions were supplied to 24 indenters *viz.*, NRCG (346), ICAR institutes (11) and various universities (955) to support the ongoing crop improvement programmes. Three hundred and twenty-two accessions were multiplied in sufficient quantity and deposited with NBPGR for long-term conservation.
- One hundred and eighty-four mini core accessions of groundnut were characterized for 19 qualitative and 27 quantitative traits at NRCG Junagadh and MPKV, Jalgaon. High coefficient of variability (CV %) was recorded for pod yield [(g)/plant and per m^{-2}], pod length and 100 seed weight at both the locations whereas at Jalgaon, the variation observed for seed length and seed width was much higher than those observed under Junagadh conditions.
- Released varieties (120) were characterized for 19 qualitative and 27 quantitative traits. The varieties were also characterized on the basis of DUS guidelines and a few distinct morphological traits were identified for each of these varieties
- True hybrids were obtained in all the cross combinations, except J11 x *A. rigonii*.
- Phenotypic ratios of F_1 and F_2 generations revealed that 'crinkled-leaf' and 'white-testa' versus 'crinkled-leaf' and 'red-testa' segregated independently and were monogenic in nature.
- One hundred and fifty advanced breeding lines were screened against salinity under pot conditions.
- Relationship among the available accessions of wild *Arachis* species was worked on the basis of molecular markers.
- The genotypes GG 20, NRCG CS 19, ICGVV 86590, PBS 24030 and GPBD 4 and their crosses with NRCG CS 19 were analyzed for polymorphlsim using 30 SSR primers.
- Sixteen cultivars having protein content higher than 25.0% were identified.

- Fourteen genotypes having oil content higher than 50.0% were identified. The oil content of the kernels of the core germplasm collection (126 genotypes) was in the range of 40.6 to 50.8% with a mean of 45.4% while the protein content was in the range of 18.2 to 29.8% with a mean of 25.1%.
- Developing groundnut kernels contained appreciable amounts of vitamin C (1-3mg/100g) which gradually decreased with increasing maturity of pods.
- Genotypic differences were discerned in the allergen content of 19 cultivars.
- *Chapati* prepared from wheat and groundnut composite flour (80:20) was adjudged to be the best from the organoleptic point of view.
- A new recipe 'Groundnut chat' was found acceptable.
- Three microorganisms *viz., Bacillus amyloliquefaciens* (amylases producing) and *Bacillus* sp. and *Aspergillus oryzae* (both protease producing) when cultured on groundnut de-oiled cake also produced other enzymes. The extracts of *B. amyloliquefaciens* also contained cellulase and protease while that of *Bacillus* sp.and *A.oryzae* contained cellulase and amylase. The amylase produced by *Bacillus amyloliquefaciens* lost about 50% of its activity during storage (4°C) for two months.
- The protease production potential of *Bacillus subtilis* P5 was successfully enhanced through UV mutation.
- A repository of isolates of *Aspergillus* at NRCG was developed having 417 isolates of *Aspergillus* spp. (mostly *A. flavus* and *A. ochraceus*). The repository is being maintained as single spore cultures on agar slants and also under long-term storage as lyophilized culture.
- Four isolates of *Trichoderma* spp. *viz.* NRCG T12, NRCG T16, NRCG T 32 and NRCG T 34 were found to be highly antagonistic to *Aspergillus flavus* ($\geq$ 45% inhibition of growth) which completely overgrew the pathogen in 5 days.
- Using the commercial kit for microbial AFLP (invitrogen), the protocol for AFLP of *A. flavus* was standardized and optimized.
- DNA Polymorphism could be detected among sixteen isolates of *A. flavus* with similar morphology but differing in toxigenicity.
- Twenty advanced groundnut breeding lines/genotypes showed tolerance of *A. flavus* infection and subsequent aflatoxin contamination over the seasons during 2006.
- The pre-harvest integrated aflatoxin management package evaluated over the seasons significantly prevented aflatoxin contamination.
- The socio-economic status of groundnut farmers of Junagadh district was medium to high.
- GG 20, GG 2, GAUG 10, and Punjab 1 are very popular varieties among the farmers.
- The adoption of optimum nutrient management (NPK and micro-nutrients) practices and application of biofertilizers were quite low.
- The major diseases of groundnut were stem rot and collar rot. Farmers would prefer a variety similar to GG 20 but resistant to stem rot.
- Majority of the farmers were not aware of aflatoxin contamination of groundnut.
- Fresh crosses were effected to incorporate the trait of large seed size. Phenotypic selections were carried out in F_5 and F_6 generations and 37 selections were made.
- Segregating materials in F_3 generation of 10 crosses made for improving seed size were supplied to eight AICRP(G) centers

Large seeded advanced breeding line PBS 29080 was proposed for evaluation under AICRP (G) trials. Advanced breeding line ICGV 99101 was evaluated under LSVT of AICRP (G) during *kharif* 2006.

The genotypes, ICGV 89214, ICGV 97061, ICGV 99101, PBS 29035, PBS 29078, ICGV 97051, PBS 29047, PBS 29079 A, PBS 29073 and PBS 29069 did not support any seed colonization by *A. flavus* (isolate AF 111) under laboratory screening.

During peak season, in Junagadh, low and high capacity *chikki* industries generated a total of 3225 and 4200 man-hours employment per month, respectively, whereas during the off-season, the employment generated was only 960 and 740 man-hours. A similar trend in employment is noticed in salted groundnut industries.

The major cost of production in *chikki* and salted groundnut industries was the variable especially that of the major raw material i.e. kernel.

Fifteen back cross and five new interspecific crosses were attempted

Seventy-nine single plant and 83 bulk interspecific progenies were advanced to the next generation.

Two isogenic mutant lines ('crinkled leaf-red testa' and 'crinkled leaf-white testa') for kernel colours, and 3 large seeded, early Spanish groundnut genotypes *viz.*, NRCG CS 148, 268 and 281 were developed.

The genotype NRCG CS 85 with promising resistance to PBND was developed.

Picloram alone was more effective in inducing leaf callogenesis in *A. prostrata* than the combination NAA and 2,4-D. Picloram in combination with either BAP or thidiazuron (TDZ) was more responsive in inducing leaf callogenesis in *A. prostrata* than NAA and 2,4-D.

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

(CHUNI LAL, A. L. RATHNAKUMAR, K. HARIPRASANNA, VINOD KUMAR, T. V. PRASAD, P. C. NAUTIYAL AND A. L. SINGH)

Hybridization

During *kharif* 2006, a total of 45 crosses were attempted for incorporating resistance to different biotic stresses (15 crosses) and to study the inheritance of morpho-physiological traits associated with high water-use efficiency/drought tolerance (30 crosses following modified triple-test cross). Out of 11,520 hand pollinations made, at the time of harvest only about 14% could be recovered as the probable hybrid pods. The poor rate of success in artificial hybridization could be attributed to the unfavorable weather conditions (excessive and continual rains) that prevailed at the crucial stages of crop growth.

Selections and generation advancements

On the basis of hybrid vigor in F_1 and non-segregation in F_2 generations, 20 F_1s and 36 F_2s, developed during previous year, were identified as true hybrids. Only 184 single plant selections could be made in various filial generations (F_3 to F_6) in the crosses attempted in the previous years for incorporating resistance to different biotic and abiotic stresses. In most of the cases, no selections could be made as the pod bearing was extremely poor. In such cases, after harvest, the produce was bulked as such and advanced for next respective filial generation.

Multiplication and maintenance of advanced breeding lines

In *kharif* 2006, a total of 397 advanced breeding cultures, developed under the project were raised for maintenance.

Screening of advanced breeding lines for resistance to biotic stresses at hot spot locations

Screening for resistance to PBND at Raichur

In *rabi*-summer 2005-06 and *kharif* 2006, respectively, 21 and 23 advanced breeding lines along with a susceptible check variety KRG 1 were screened for reaction to PBND. In both the seasons, a low incidence of PBND was observed in the advanced breeding lines PBS 16020 and PBS 16021. Since, there was sufficiently high incidence of PBND during both the seasons, these advanced breeding lines (Table 1) were considered to be resistant to PBND.

Table 1. Reaction of advanced breeding lines to PBND at Raichur

Sr. No.	Advanced breeding lines	Disease incidence (%)	
		Rabi-summer 2005-06	*Kharif* 2006
1.	PBS 16020	8.59	4.20
2.	PBS 16021	12.95	10.00
3.	KRG1 (susceptible check)	21.95	46.00

Screening for resistance to foliar fungal diseases (rust and late leaf spots) at Raichur

During *kharif* 2006, 17 advanced breeding lines along with susceptible check KRG 1 were screened for resistance to late leaf spot (LLS) and rust. The rust incidence was, however, too low. In case of LLS, on a modified 9-point scale, the maximum score of 8 was recorded in the susceptible check KRG 1. Six advanced breeding lines were assigned a score of 3, and hence considered to be resistant to LLS (Table 2).

Table 2. Reaction of advanced breeding lines to rust and late leaf spot (LLS) at Raichur

Sr. No.	Advanced breeding line	Disease score (1-9 scale)	
		Rust	LLS
1.	PBS 12163	2	3
2.	PBS 12167	2	3
3.	PBS 13018	3	3
4.	PBS 15011	2	3
5.	PBS 30046	3	3
6.	PBS 30086	3	3
	KRG 1 (check)	5	8

Screening for resistance to stem rot in sick plot at Dharwad and Jalgaon

Twenty advanced breeding lines were screened for resistance to stem rot in sick plot conditions at Dharwad (*rabi/* summer 2005-06) and 23 at Jalgaon (*kharif* 2006). Highest incidence of stem rot was recorded in PBS 16020 at Dharwad and in TG 26 (54.7%) at Jalgaon. Compared to these high levels of infection, the advanced breeding line PBS 18064 recorded low infection of stem rot at both the locations. In addition, low incidences of stem rot was also observed in the advanced breeding line PBS 15011 at Jalgaon. Hence, compared to the incidence of stem rot in the susceptible genotypes, these two genotypes were be considered to be resistant to stem rot (Table 3).

Table 3. Stem rot incidence in advanced breeding lines grown at Dharwad and Jalgaon

Location and season	Stem rot affected plants (%)			
	Advanced breeding line		Susceptible check	
	PBS 18064	PBS 15011	PBS 16020	TG 26
Dharwad (summer 2006)	13.0	-	84.0	-
Jalgaon (*kharif* 2006)	13.2	14.3	-	54.7

X[th] International short duration groundnut varietal trial -2006

Fourteen test entries from ICRISAT were evaluated at NRCG along with two check varieties, viz., Chico and GG 7 in a triple lattice square design in *kharif* 2006. Among the several traits studied, for days to 75% flowering, three genotypes (ICGV 00298, ICGV 99211 and ICGV 01020) recorded significantly fewer number days than the best check GG 7 (Table 4).

Table 4. Performance of early maturing advanced breeding lines obtained from ICRISAT

Sr. No.	Identitiy of culture	Days to flower initiation	Days to 75% flowering	SCMR*	Pod yield (kg/ha)**
	Test entry				
1	ICGV 00321	23	26	23	373
2	ICGV 99219	24	27	25	344
3	ICGV 00290	25	27	24	324
4	ICGV 00298	23	24	28	243
5	ICGV 99211	21	24	25	232
6	ICGV 01020	21	24	23	151
	Check				
1	Chico	23	26	23	246
2	GG 7	20	25	27	323
	Population mean	23	25	24	259
	Range	20 - 25	24 - 28	21 - 28	151 - 373
	CV (%)	2.8	2.6	4.4	22.2
	CD (5%)	1	1	2	96

*SCMR = SPAD chlorophyll meter reading; **due to untimely and excessive rains the yields were quite low in *kharif* -2006.

Groundnut varietal blends as an insurance against drought

Eight water-use efficient lines, two each performing best under irrigated, IR (Jun 7, Jun 8); early-season drought, ESD (Jun 39, Jun 40); mid-season drought, MSD (Jun 37, Jun 46); and late season drought, LSD (Jun 27, Jun 38) situations, were used for preparing varietal blends. Seeds of any two genotypes within the group or across the groups were mixed in 1:1 ratio in all possible combinations to produce 28 bi-blends. These 28 bi-blends were evaluated along with the 8 component lines in a split plot design with drought pattern as main plot treatment and genotype(s) as sub-plot treatment. Under each drought pattern, these entries were sown in a RBD with two replications. Each treatment comprised 2 rows of 3 m each.

The variation due to genotypes was highly significant under irrigated and early-season drought situations. It was, however, not significant under mid- and end-of-season drought situations. Compatibility analysis based on the combining ability suggested by Griffings' Model I, Method II revealed that variance due to both general and specific compatibility was highly significant under all the four drought patterns. General compatibility effects revealed that compatibilities of component lines Jun 7 and Jun 40 were good across the varietal mixtures, whereas for Jun 38 and Jun 39, it was poor under all patterns of drought situations.

Specific compatibility effects were found to be significant in 13, 14, 17 and 10 bi-blends under irrigated, early-season, mid-season and end-of-season drought situations, respectively.

Comparative studies on seasonal effects on selections

Forty advanced breeding lines, 10 each derived from a cross Chico x R33-1 and its reciprocal in both *kharif* and summer seasons, were evaluated also in both summer 2006 and *kharif* 2006 seasons along with their parental lines to understand if the selections made in summer or *kharif* seasons performed better in the respective seasons only or across seasons. Results showed that in both the seasons, crop performance was very poor. In summer, low temperature prevailing at the time of germination delayed the process and affected early plant vigor and perhaps the high temperatures coinciding with the flowering stage hampered the pollination and fertilization process. Hence, this experiment will be repeated for one more summer and *kharif* season.

Station trials for yield evaluation

Advanced breeding lines developed for different biotic and abiotic stresses were evaluated in RBD with three replications in two-row plot size each of 3 m length in preliminary yield evaluation trial for one year and in four-row plot size in advanced yield evaluation trial for two years. Three checks, GG 2 (local check, LC), SB XI (zonal check, ZC) and JL 24 (national check, NC) were used for comparison in Spanish group and four checks, namely GG 20, Kaushal, M 335 and Somnath were used in Virginia group. Observations were recorded in different trials on SLA and chlorophyll content (expressed as SCMR) content at 55 DAS. Fodder and biological yields were recorded in five randomly selected plants in each genotype from each replication at the time of harvesting and expressed in g/plant.

Preliminary yield evaluation trial of breeding lines of Spanish groundnut

Sixteen advanced breeding lines were evaluated along with three checks in *kharif* 2006. The SCMR values ranged from 22 to 34 with mean of 27 while the pod yield ranged from 117 to 444 kg/ha averaging to 271 kg/ha over all the test entries and checks (Table 5). Among the three check varieties, SB XI gave the highest pod yield (330 kg/ha). Although none of the test entries gave significantly higher pod yield over this check variety, four test entries had numerically higher pod yields over the best check SB XI. For SCMR, however, four entries recorded significant higher values than the best check variety, GG 2 for this trait.

Table 5. Pod yields and SCMR values of some of the selected Spanish groundnut entries evaluated in preliminary trial in *kharif* 2006

Sr. No.	Genotype	Pod yield (kg/ha)	SCMR*
	Test entry		
1	PBS 11084	444	29
2	PBS 14060	366	28
3	PBS 14066	441	26
4	PBS 16026 A	275**	30
5	PBS 16026 B	210**	31
6	PBS 16039	414**	34
7	PBS 19017	191**	30
	Check		
8	GG 2	178	27
9	JL 24	293	23
10	SB XI	330	24
Population mean		271	27
Range		117-444	22-34
CV (%)		29.0	5.7
SEm ±		45.2	0.9
CD (5%)		129.7	2.5

*SCMR = SPAD chlorophyll meter reading; **due to untimely and excessive rains the yields were quite low in *kharif*-2006.

Table 6. Features of flowering, SPAD chlorophyll meter reading (SCMR) and pod yield of some of the selected Spanish groundnut entries evaluated in advanced Spanish groundnut trial in *kharif* 2006

Sr. No.	Genotype	Days to flower initiation	Days to 50% flowering	SCMR	Pod Yield (kg/ha)*
	Test entry				
1	PBS 11046	26	30	31	416
2	PBS 11056	26	29	33	350
3	PBS 11057	26	29	33	290
4	PBS 11074	20	24	25	173
5	PBS 11075	20	24	24	191
6	PBS 11076	20	23	23	205
7	PBS 12167	24	28	30	177
8	PBS 15011	25	28	30	257
9	PBS 16025	26	28	33	365
10	PBS 16027	25	28	30	351
11	PBS 16031	25	28	33	424
12	PBS 16032	25	29	33	406
13	PBS 16033	23	26	32	510
14	PBS 16035	25	28	30	364
15	PBS 16038	25	27	35	346
16	PBS 16040	25	28	30	352
17	PBS 30053	23	25	26	328
18	PBS 30067	20	22	28	254
19	PBS 30104	20	23	22	231
	Check				
20	GG 2	22	25	26	192
21	JL 24	25	28	23	261
22	SB XI	24	26	26	260
Population mean		24	27	27	280
Range		20-26	22-30	22-35	157-510
CV (%)		2.8	3.7	5.9	30.8
SEm ±		0.39	0.56	0.92	49.76
CD (5%)		1.1	1.6	2.6	140.0

*Due to untimely and excessive rains the yields were quite low in *kharif*-2006.

Preliminary yield evaluation trial of breeding lines of Virginia groundnut

Thirteen advanced breeding lines of Virginia groundnut along with four check varieties were evaluated in preliminary yield performance in *kharif* 2006. The SCMR values ranged from 26 to 34 with an average of 31. The highest SCMR value of 34 was recorded in PBS 21087 and PBS 22053. The pod yield ranged was too low and was in the range of 159 to 384 kg/ha (Table 7). The highest pod yield obtained in trial was that of the check variety GG 20. As yields obtained were very poor the trial was not considered to derive any conclusion.

Advanced yield evaluation trial of Spanish breeding lines of groundnut

Thirty-nine advanced breeding lines of Spanish groundnut including three lines from ICRISAT were tested along with three checks in *kharif* 2006. Five genotypes recorded minimum number of days to initiate flowering. The genotype PBS 30067 also took the least number of days to complete 50% flowering (Table 6). Highest SCMR value was recorded in the genotypes PBS 16038. However, the pod yield ranged from only 157 to 510 kg/ha. Five test entries took significantly lesser number of days (20) to initiate flowering compared to check variety GG 2. Similarly test entries PBS 11076, PBS 30067 and PBS 30104 took significantly lesser number of days to complete 50% flowering on plot basis. For SCMR, as many as 13 test entries recorded significantly superior values over the best checks GG 2 and SB XI for this trait. Highest pod yield was recorded in JL 24 among the checks, and four test entries gave significantly higher pod yields over this check. As yields obtained were very poor, the trial was rejected and not considered for drawing any conclusion.

Table 7. Pod yield and SPAD chlorophyll meter reading (SCMR) of selected Virginia groundnut entries evaluated in preliminary yield trial in *kharif* 2006

Sr. No.	Genotypes	Pod yield (kg/ha)*	SCMR
	Test entry		
1	PBS 24090	341	33
2	PBS 24096	322	29
3	PBS 24092	316	31
4	PBS 22053	259	34
5	PBS 21087	240	34
	Check		
6	GG 20	384	31
7	Kaushal	182	33
8	M 335	205	29
9	Somnath	308	31
Population Mean		256	31
Range		159 - 384	26 - 34
CV (%)		26.1	3.7
CD (5%)		111	2

*Due to untimely and excessive rains the yields were quite low in *kharif*-2006.

Advanced yield evaluation trial of breeding lines of Virginia groundnut

Twenty-two advanced breeding lines of Virginia groundnut were evaluated along with four check varieties in *kharif* 2006. PBS 30162 was found to be the most early in flowering as it took only 20 days to initiate flowering and 24 days for 50% of its plants to flower. The SCMR readings, for all the genotypes (test entries + checks) were in the range of 28 to 38 with an average value of 33. Six test entries performed significantly better than the best check variety Kaushal, for this trait (Table 8). Three test entries, namely PBS 26014, PBS 26015 and PBS 26021 registered significantly superior pod yields over the best check variety, M 335.

Table 8. Features of flowering, SPAD chlorophyll meter reading (SCMR), and pod yield of some of the selected Virginia groundnut entries evaluated in advanced Virginia groundnut trial in *kharif* 2006

Sr. No.	Genotypes	Days to flower initiation	Days to 50% flowering	SCMR	PodYield (kg/ha)*
	Test entry				
1	PBS 21057	28	32	35	205
2	PBS 22046	28	32	38	301
3	PBS 25003	25	28	36	169
4	PBS 26010	28	31	36	183
5	PBS 26014	25	27	32	306
6	PBS 26015	26	28	32	329
7	PBS 26019	26	28	36	183
8	PBS 26021	24	27	36	302
9	PBS 30162	20	24	30	182
	Check				
10	GG 20	25	28	31	171
11	Kaushal	27	31	32	151
12	M 335	25	29	31	213
13	Somnath	27	29	30	165
Population mean		26	29	33	172
Range		20 - 30	24 - 35	28 - 38	86 - 301
CV (%)		4.1	4.5	4.2	25.6
CD (5%)		1.7	2.1	2.3	87.3

*Due to untimely and excessive rains the yields were quite low in *kharif* 2006.

Advanced cultures under AICRP-Groundnut trials

Three advanced cultures, JUG 27, PBS 24004 and PBS 12160 were evaluated in IVT in *kharif* 2006. One culture, PBS 24030, which performed well in Zone I comprising Rajasthan, Uttar Pradesh, Punjab and Haryana, was identified for release and notification as Girnar 2.

Supply of segregating material to AICRP-Groundnut Centres

Information on the availability of segregating material in different generations was circulated among all the AICRP-Groundnut centres. Segregating materials (F_3 to F_6 generations) of 34 crosses attempted for different breeding objectives was supplied to 11 AICRP-Groundnut centres namely, Hanumangarh, Udaipur, Dharwad, Bhavanisagar, Chintamani, Rahuri, Latur, Junagadh, Anand, Digraj, and Almora.

PROJECT 02: INTEGRATED PEST MANAGEMENT (IPM) IN GROUNDNUT BASED PRODUCTION SYSTEM

(M.P. GHEWANDE*, VINOD KUMAR AND T.V. PRASAD)

* Up to July 2006

Sub-project 1: Integrated insect and non-insect pest management in complex, diverse and risk-prone (CDR) groundnut based production system

(T.V. Prasad)

Yield loss in groundnut due to artificial defoliation

Field experiments were conducted during post-rainy seasons of 2005 and 2006 to understand the yield loss mechanism when a definite portion of leaf area is removed, which in turn simulated the damage by insects. The cultivar GG 2 was sown in 3 rows of 2 m length at 45 cm spacing between rows and 10 cm within a row. There was a gap of 2 m all around the plot. The treatments included four levels of defoliations *viz.*, 0, 2, 5, and 10% at different phenophases of crop such as vegetative, pegging, pod filling and their combinations. The defoliation was carried out in such a way that 60 % of the upper leaves and 40 % of the lower leaves were removed representing a particular percent of defoliation. Each treatment was replicated thrice.

The results of pooled data over two years indicated that with increase in extent of defoliation the yield loss also increased significantly in all the stages and in their combinations except during vegetative stage. The pod yield was significantly affected by defoliation during different growth stages. In this experiment the highest pod yield was obtained when defoliation (2%) was done during the vegetative stage (1617 kg/ha) and this was followed by the control (1539 kg/ha) where the plants were not defoliated at all (Table 1).

Results showed that pod yield decreased with increase in the extent of artificial defoliation and the decrease was more when defoliation was done in the advanced stages of the crop growth. Pod yield was lowest (910 kg/ha) when the plants were defoliated (10%) during pegging + pod filling stage. Though there was a significant variation in the per cent oil content, shelling percentage and per cent sound mature kernel (SMK) with increase in percentage defoliations in all the stages and in their combinations but no linear relationship was observed with respect to percentage defoliation (Fig. 1).

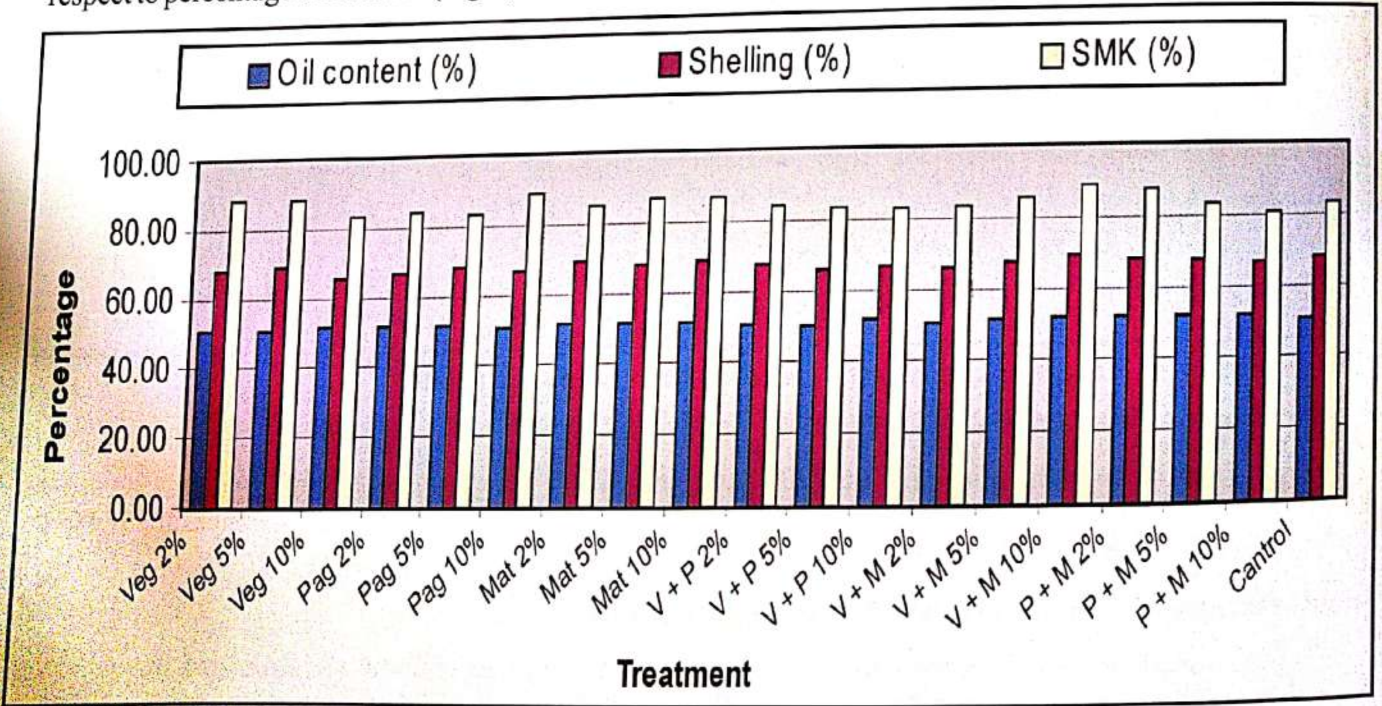

Figure 1. Effect of artificial defoliation during various growth stages and their combinations on oil content, SMK and shelling turnover

Table 1. Effect of artificial defoliation in different phenophases on pod yield during 2005 and 2006

Defoliation (%)	Phenophase	Pod yield (kg/ha)		
		2005	2006	Pooled
2	Vegetative	1492	1741	1617
5	Vegetative	1338	1724	1531
10	Vegetative	1238	1688	1463
2	Pegging	1298	1584	1441
5	Pegging	1270	1537	1404
10	Pegging	1219	1519	1369
2	Pod-filling	1035	1496	1266
5	Pod-filling	974	1474	1224
10	Pod-filling	954	1472	1213
2	Vegetative + pegging	1136	1361	1248
5	Vegetative + pegging	952	1330	1141
10	Vegetative + pegging	927	1326	1126
2	Vegetative + pod-filling	1051	1326	1189
5	Vegetative + pod-filling	883	1242	1062
10	Vegetative + pod-filling	837	1230	1033
2	Pegging + pod-filling	1018	1205	1111
5	Pegging + pod-filling	925	1178	1051
10	Pegging + pod-filling	772	1048	910
0	Control	1347	1730	1539
Mean		1088	1432	
S. Em.±		121	131	89
CD (5%)		348	376	252
CV (%)		19	16	17
Year				
SEm.±				29
CD (5%)				82
Year x treatment				
SEm.±				126.32
CD (5%)				NS

Evaluation of botanical powders for the management of storage insect pest, *Caryedon serratus* Olivier

A laboratory trial was conducted to evaluate botanical powders for the management of *Caryedon serratus*. The insecticides, Fenvalerate and Methyl parathion at 1% completely protected the groundnut pods as none of the adults were able to emerge. Oviposition (33.33 mean no. of eggs/100 g pods) and percentage pod weight loss was minimum at 1% custard apple seed powder and percentage adult emergence was minimum at 1% *Lantena camara* leaf powder compared to control and other botanicals tested against *Caryedon serratus* (Table 2).

Table 2. Effect of botanicals on the oviposition and adult emergence of bruchid beetle (*Caryedon serratus*)

Treatment	Rate of application (w/w)	Eggs laid (no./100 g pod)	Adult emergence (%)	Loss of pod mass (%)
Lantena camara leaf powder	1%	56.67	78.67	4.92
Custard apple seed powder	1%	33.33	83.33	3.68
Fenvalerate (0.4% dust)	1%	3.67	0.00	1.68
Methyl parathion (2% dust)	1%	3.00	0.00	1.81
Control		69.00	97.08	5.68
SEm±		15.13	8.95	1.21
CD (5%)		43.1	25.23	3.45
CV (%)		45.01	20.98	42.32

Evaluation of various receptacles for the management of bruchid beetle (*Caryedon serratus* Olivier)

Among different receptacles evaluated for the management of *Caryedon serratus,* fertilizer bags were found suitable as oviposition and mean number of adults emerged was low (2.3 mean no. of eggs/100 g pods and 10.3 mean no. of adults emerged/5 kg pod) compared to other receptacles tested (Table 3).

Table 3. Preference for oviposition and adult emergence of *Caryedon serratus* Olivier on various receptacles

Receptacle	Adults (no./5 kg pods)	Eggs laid (no./100g pods)
Bamboo basket with cow dung layer	31.0	312.7
Bamboo basket	85.0	281.7
Fertilizer bag	10.3	2.3
Polythene lined gunny bag	44.3	20.0
Cotton bag	28.0	24.3
Ordinary gunny bag	44.3	134.7
SEm±	13.79	17.11
CD (5%)	42.49	52.72
CV (%)	58.9	22.8

Studies on correlation between oviposition and adult emergence of *Caryedon serratus* O. on groundnut kernels

Laboratory experiments were carried out to study the correlation between oviposition and adult emergence of *C. serratus* on single matured bold kernel and wrinkled kernel of GG 20.

On bold kernels, results indicated that a maximum of 3 adults/kernel emerged irrespective of the number of eggs laid on the kernel ranging from 1 to 10 eggs/kernel. The number of exit holes/kernel were positively correlated (equal) to the adults emerged (r = 0.62). Percent weight loss per kernel increased as the number of eggs/kernel increased. There was no significant difference between the length, width and weight of adults emerged among different treatments.

On wrinkled kernels, results indicated that a maximum of 4 adults/kernel had emerged irrespective of the number of eggs on the kernel ranging from 1 to 10 eggs/kernel. The number of exit holes/kernel positively correlated (equal) with the adults emerged (r = 0. 62). Percent weight loss per kernel increased as the number of eggs per kernel increased. There was no significant difference between the length, width and weight of adults emerged among different treatments.

Integrated Pest Management in groundnut based intercropping system

An IPM experiment in groundnut based intercropping system was taken up during *kharif* 2006 with groundnut cultivar GG 20 and intercrops *viz*., Bajra (Mh 179), Sorghum (local), Maize (local), Castor (GAUCH 1), Pigeon pea (BDN 2), Cowpea (local), Green gram (local) , Black gram (local) and Sesame (local) used in the ratio of 9:1 with three replications.

The cowpea as an intercrop was found to be suitable in reducing the jassids population compared to other intercrops with groundnut and sole groundnut (Table 4). With sorghum and maize as intercrops the population of thrips was higher while with pigeonpea as intercrop it was lower than the sole groundnut crop (Table 5).

Table 4. Effect of groundnut based cropping system on the incidence of jassids

Cropping system	No. of jassids/5 sweeps				
	30 DAS	45 DAS	60 DAS	70 DAS	Mean
Groundnut + cowpea	5.67	18.67	32.00	15.67	18.00
Groundnut + green gram	4.00	20.33	20.67	10.00	13.75
Groundnut + black gram	3.00	27.67	29.33	11.00	17.75
	4.00	19.67	32.33	18.67	18.67
Sole groundnut	7.00	30.00	43.33	18.00	24.58
SEm±	1.24	2.10	2.19	1.84	
CD (5%)	NS	6.23	6.50	NS	
CV (%)	44.59	16.64	13.51	21.20	

Table 5. Effect of groundnut based cropping system on the incidence of thrips

Cropping system	No. of thrips/5 sweeps				
	30 DAS	45 DAS	60 DAS	75 DAS	Mean
Groundnut + sorghum	5.00	8.00	2.33	4.67	5.00
Groundnut + maize	6.33	4.33	6.00	3.33	5.00
Groundnut + pigeon pea	4.57	4.00	2.67	4.33	3.92
Sole Groundnut	5.00	8.67	7.00	5.00	6.42
SEm ±	0.79	0.66	0.49	0.85	
CD (5%)	NS	1.96	1.45	NS	
CV (%)	26.24	20.36	22.45	35.17	

Based on the cost of cultivation and the yields of groundnut and the intercrop, the CBR was worked out. Intercropping with castor gave highest CBR (1: 1.95) followed by pigeonpea (1: 1.86). The yield economics worked out has shown that intercropping with castor gave the highest income of Rs. 26, 945 followed by pigeonpea (Rs. 25,713) compared to other intercrops (Table 6).

Table 6. Effect of groundnut based intercropping system on the yield and yield economics

Treatment	Yield (kg/ha)		Gross returns (Rs/ha)	Cost of cultivation (Rs/ha)	C:B ratio
	Groundnut	Intercrop			
Groundnut + bajra	487.3	44.1	12624	12410	1.02
Groundnut + sorghum	482.8	*	12069	12410	0.97
Groundnut + maize	408.8	*	10219	12410	0.82
Groundnut + sesame	424.8	32.4	11593	13200	0.88
Groundnut + castor	459.3	1030.8	26945	13800	1.95
Groundnut + pigeon pea	333.0	1159.2	25713	13800	1.86
Groundnut + cowpea	399.6	175.1	12966	12800	1.01
Groundnut + green gram	390.1	271.2	13821	12800	1.08
Groundnut + black gram	424.0	294.4	15017	12800	1.17
Sole groundnut	579.2	--	14481	12000	1.21
SEm±	11.3				
CD (5%)	33.5				
CV (%)	14.4				

Basic cost of cultivation of groundnut = Rs. 12,000/ha. * Yield could not be recorded due to damage by birds

Though, the results of the present study indicated that intercropping has significant effect on yield and yield economics of groundnut but it has no significant effect on shelling turnover and sound mature kernels (%).

Screening of segregating, stabilized lines and released cultivars of groundnut against major insect pests

Out of 31 genotypes screened for resistance to jassids under field conditions during the rainy season of 2006, NRCG-CS nos' 101, 109, 243 and 272 were found moderately resistant (< 9 mean no. of jassids/5 sweeps) and NRCG-CS nos' 214, 247, 251, 254, 263, 266, 280, 289 and 301 were found susceptible (recording >20 mean no. of jassids/5 sweeps) compared to other genotypes tested (Table 7). In case of thrips, however, none of the genotype was found to be free from thrips infestation.

Table 7. Screening of genotypes developed by Cytogenetics section for resistance to sucking pests

Genotype	Jassids (No./5 sweeps)			Thrips (No./5 sweeps)		
	P1	P2	Mean	P1	P2	Mean
NRCG-CS 101	7.7	10.0	8.8	2.3	0.7	1.5
NRCG-CS 109	9.3	8.0	8.7	2.0	1.0	1.5
NRCG-CS 214	25.3	24.0	24.7	4.7	3.7	4.2
NRCG-CS 247	23.3	22.3	22.8	2.7	2.0	2.3
NRCG-CS 251	23.0	22.0	22.5	3.7	3.3	3.5
NRCG-CS 263	22.3	18.0	20.2	3.0	2.3	2.7
NRCG-CS 266	26.0	23.7	24.8	4.7	1.7	3.2
NRCG-CS 272	6.7	8.3	7.5	1.3	0.3	0.8
NRCG-CS 280	21.3	20.7	21.0	4.7	2.3	3.5
NRCG-CS 297	14.0	12.0	13.0	2.3	2.0	2.2
NRCG-CS 298	15.7	17.7	16.7	3.7	2.3	3.0
NRCG-CS 301	21.0	21.0	21.0	2.3	3.0	2.7
GG 2	18.3	18.7	18.5	2.7	0.3	1.5
GG 7	8.7	7.3	8.0	2.3	1.0	1.7
SEm. ±	4.35	2.78		0.95	0.58	
CD (5%)	12.31	7.87		NS	1.64	
CV (%)	48.37	31.26		58.71	57.4	

Out of 57 released Spanish bunch varieties screened for resistance to sucking pests and defoliators, none was found free from jassids and defoliators infestation. In case of thrips, varieties AK159, OG 52-1 and VRI 4 and were found moderately resistant recording < 7 mean numer of thrips/m row and varieties R 8808 and ICGS 44 were found susceptible recording > 18 mean number of thrips/m row (Table 8).

Table 8. Screening of released Spanish bunch varieties for resistance to major insect pests of groundnut

Cultivars	Jassids (No./5 sweeps)			Thrips (No./5 sweeps)			Damage caused by jassids (%)			Damage caused by defoliators (%)		
	P1	P2	Mean	P1	P2	Mean	P1	P2	Mean	P1	P2	Mean
AK12-24	8.3	2.7	5.5	4.7	16.0	10.4	11.8	2.3	7.1	4.8	8.7	6.8
AK 159	5.3	2.0	3.7	2.0	10.3	6.2	7.1	3.7	5.4	2.3	5.3	3.8
ICGS 44	16.0	2.0	9.0	5.0	34.7	19.9	12.0	7.2	9.6	3.8	2.8	3.3
Kadiri 5	5.0	1.0	3.0	3.7	11.7	7.7	5.3	3.7	4.5	4.8	3.2	4.0
OG 52-1	5.0	2.0	3.5	2.3	10.7	6.5	7.8	4.5	6.2	2.0	10.0	6.0
R 8808	8.3	2.0	5.2	3.7	34.0	18.9	11.3	7.8	9.6	4.2	4.3	4.3
VRI 3	4.3	1.0	2.7	2.7	29.0	15.9	8.7	4.8	6.8	7.2	6.3	6.8
VRI 4	7.7	1.7	4.7	2.0	9.7	5.9	3.7	3.7	3.7	1.2	5.0	3.1
SEm ±	2.47	0.72		1.46	3.58		2	1.6		1.9	2.04	
CD (5%)	NS	NS		4.08	10.04		5.6	4.6		NS	NS	
CV (%)	54.4	64.4		53.7	33.4		44.1	54.4		54.3	67.1	

Out of 51 released varieties (VB) screened for sucking pests and defoliators none of the varieties was free from thrips and defoliators infestation. In case of jassids, varieties Chitra MH 2 and CSMG 84-1 were found moderately resistant recording < 7 mean number of jassids/m row and varieties DRG 17, DSG 1, ICGV 86325 and LGN 2 were susceptible recording > 19 mean number of jassids/m row (Table 9).

Table 9. Screening of released Virginia bunch varieties for resistance to major insect pests of groundnut

Cultivar	Jassids (No./5 sweeps)			Thrips (No./5 sweeps)			Damage caused by jassids (%)			Damage caused by defoliators (%)		
	P1	P2	M	P1	P2	M	P1	P2	M	P1	P2	M
B 95	9.7	12.7	11.2	1.0	2.0	1.5	6.5	3.2	4.9	4.3	3.2	3.8
BAU 13	11.7	12.7	12.2	1.0	3.0	2.0	5.5	3.3	4.4	7.8	3.7	5.8
Chandra	7.7	12.3	10.0	1.3	2.3	1.8	7.0	6.5	6.8	2.0	4.2	3.1
Chitra	4.3	6.7	5.5	0.3	2.0	1.2	5.2	2.8	4.0	2.8	3.0	2.9
M 522	8.0	9.3	8.7	1.0	1.7	1.4	7.7	5.2	6.5	4.0	1.0	2.5
MA 16	8.3	16.0	12.2	1.3	3.0	2.2	4.2	3.2	3.7	5.3	2.7	4.0
MH 2	3.7	6.0	4.9	0.0	1.0	0.5	4.0	1.3	2.7	3.8	1.2	2.5
MH 4	5.7	8.7	7.2	1.0	1.3	1.2	2.5	1.5	2.0	6.8	3.3	5.1
UF 70-103	8.3	16.7	12.5	1.0	4.0	2.5	3.2	4.7	4.0	2.5	1.7	2.1
SEm ±	2.5	3.9		0.7	0.9		1.3	1.09		1.41	1.6	
CD (5%)	6.9	NS		1.9	NS		3.7	NS		NS	NS	
CV (%)	45.5	43.3		77.5	57.1		39.35	48.7		55.5	71.1	

P1- vegetative phase (30 DAE); P2- flowering and pegging phase (45 DAE); — mean

Effect of bio-pesticides on sucking insect pests of groundnut

Among various biopesticides tested for their efficacy against sucking pests of groundnut, *Beauveria bassiana* @ 2 g/L gave good control of jassids, and *Verticillium lecanii* @ 2 g/L was effective against thrips at 15 days after treatment compared to other treatments and control.

Development of efficient traps against sucking pests of groundnut

Out of seven different types and colours of traps evaluated against sucking pests of groundnut with water and sticky materials, castor oil used as trapping material was found superior to water. Out of different colours of traps tested, yellow colour was found efficient in trapping maximum no. of aphids as well as jassids. Among the traps tested, yellow plastic tray trap was superior in trapping the highest mean no. of aphids and jassids (77.1 and 941.9, respectively) per week compared to other traps (Table 10).

Table 10. Mean number of insects trapped/week in different types of traps

Sl. No.	Type of trap	No. of insects trapped			
		Water		Sticky	
		Aphids	Jassids	Aphids	Jassids
1	Green plastic tray trap	8.0	7.0	6.7	17.0
2	Blue plastic tray trap	9.8	21.5	15.0	40.0
3	Red plastic tray trap	13.0	8.5	15.0	52.0
4	Yellow plastic tray trap	29.8	108.6	77.1	941.9
5	Yellow Wota-T trap	21.3	143.5	24.8	299.3
6	Yellow plastic plate trap	-	-	5.0	295.5
7	Yellow inverted bucket plastic trap	-	-	29.0	95.5

Monitoring of the major insect pests of groundnut

In the monitoring programme of the major insect pests of groundnut, *Helicoverpa armigera*, *Spodoptera litura* and *Aproaerema modicella* were monitored using pheromone traps. Aphids like *A. craccivora,* and *Hysteroneura setariae* were monitored using cylindrical sticky trap. The jassids and thrips were monitored using the sweep net in monthly sown crops. The aphid population was highest during November, December, January and February and declined from there onwards. Jassids were abundant during February and March. The leaf miners continued to be present in low numbers except the sudden hike in November and January (203 and 48 male moths/trap/week, respectively) (Fig 2). *Helicoverpa* moth catches were very meager, where as highest *S. litura* moths were recorded in the month of September (94 male moths/trap/week).

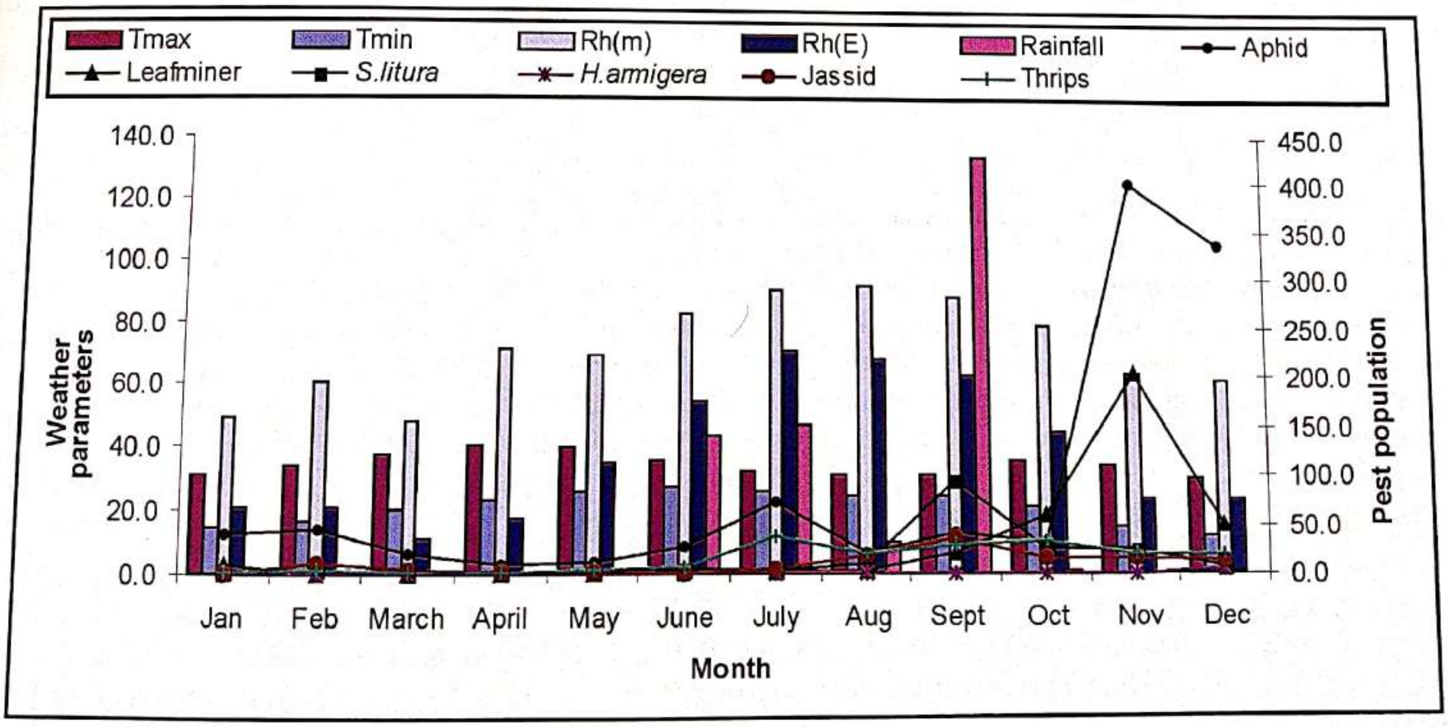

Figure 2. Monitoring of population of major insect pests of groundnut during 2006

Sub-project 02: Integrated management of major diseases (ELS, LLS, rust, collar rot, stem rot, and PBND) of groundnut

(Vinod Kumar)

Disease resistance

Summer 2006

A total of seventy-one genotypes were evaluated against peanut bud necrosis disease vis-à-vis yield of groundnut during summer 2006 under field conditions. The results indicated that the incidence of PBND ranged from 0.00 to 18.33%. Zero percent incidence of PBND was observed in the sixteen genotypes, *viz.*, CODE 7, CODE 5-3; NRCG CS nos.' -19, 25, 86, 88, 110, 116, 151, 160, 168, 186, 202 and 251; JAL 05 and JAL 36 as against the highest in PBS 11024 (18.33%) followed by GG 2 (13.39%).

The comparative data of field screening from 2003 to 2006 revealed that twenty-eight genotypes *viz.*, ALR 2, CODE 5-3, CODE 7, NRCG CS nos.' 19, 25, 86, 88, 160, 164, 168, 186, 202, 251; ICGV 86590, JAL 05, OG 52-1, PBS 11026, PBS 11037, PBS 11042, PBS 11068, PBS 12160, PBS 12169, PBS 19012, PBS 30016, PBS 30158, TIR 16, TIR 42 and UF 70-103 recorded below 5% incidence showing promising resistance/tolerance to PBND. These promising genotypes will be tested in hot spots under AICRP on groundnut once the sufficient amount of seed is available.

Twenty genotypes were evaluated against stem rot (*S. rolfsii*) in concrete block in artificially inoculated condition during the summer season of 2006. Out of these, two genotypes *viz.*, PBS 30033 and PBS 22028 showed below 20% incidence as against 52.94% in GG 20. NRCG CS 19 showed resistant reaction (13.2%) against *S. rolfsii*. Also, 20 genotypes were evaluated for resistance to collar rot pathogen (*Aspergillus niger*) under artificially inoculated concrete block condition during summer 2006. Four genotypes *viz.*, PBS 30033, PBS 21018, PBS 29080 and PBS 21073 exhibited promising resistance recording ≤ 15% incidence. A total of 47 genotypes including susceptible (GG 2) and resistant check (J 11) were evaluated against collar rot pathogen (*A. niger*) under laboratory condition by adopting dry seed resistance technique, out of which 11 genotypes *viz.*, NRCG CS nos.' 134, CS 264, CS 301, CS 306, CS 308, CS 319, CS 325, CS 329, CS 332, CS 344 and CS 353 showed resistant reaction against *A. niger* recording 10% seed colonization as against 32.85 % in GG 2.

Kharif 2006

A total of 102 genotypes (second year screening) along with susceptible checks (GG 20) were evaluated against early leaf spot (ELS), late leaf spot (LLS), rust and stem rot diseases under field conditions during the rainy season of 2006. In case of stem rot, each genotype was artificially inoculated with *Sclerotium rolfsii* pathogen at 30 days of emergence. Observations on foliar fungal diseases were recorded by adopting a 1-9 modified scale, while in the case of stem rot, the percentage of incidence was recorded before and after harvest. Observations on pod yield (g/3m row length) were also recorded. However, due to high rainfall there was continuous water-logging in the field at critical stages for infection by the pathogen and development of the disease was very low which was not sufficient for a meaningful screening against the various soil borne and foliar diseases. As also, various treatments could not be imposed in time due to nón-congenial conditions in the field.

The results revealed that the incidence of aflaroot, collar rot and stem rot disease were below 5% in majority of genotypes. The percent incidence of various soil borne diseases *viz.*, aflaroot, collar rot and stem rot were in the range of 0.0-22.92, 0.0-10.53 and 0.0-60.87, respectively. The severity of foliar diseases *viz.*, early leaf spot (ELS), late leaf spot (LLS) and rust were in the range of 1.50-5.33, 1.33- 4.83 and 1-2.17, respectively, on 1-9 scale.

The result of screening of 102 genotypes is presented in Table 1a. Eight genotypes which showed promising resistance both against ELS and LLS were NRCG CS nos.' 30, 154, 264, 268, 285, 303, 311 and 329 recording 2.0 disease severity on 1-9 scale as against 4.33 and 3.00 in susceptible check GG 20 for ELS and LLS, respectively.

Table 1a. Promising genotypes having resistance/tolerance to ELS and LLS under field conditions during rainy season of 2006 (2nd year screening)

Sr. No.	Genotype	Disease intensity (1-9 scale**)	
		ELS	LLS
1.	NRCG CS 30	1.50	1.83
2.	NRCG CS 154	1.83	1.83
3.	NRCG CS 264	1.83	1.50
4.	NRCG CS 268	1.83	1.50
5.	NRCG CS 285	1.67	1.67
6.	NRCG CS 303	1.50	1.33
7.	NRCG CS 311	1.83	1.50
8.	NRCG CS 329	2.00	1.83
9.	GG 20*	4.33	3.00

*Susceptible check

** Highest severity of ELS and LLS was 5.33 and 4.83 in the genotype CS 352 and CS 296, respectively

During *kharif* 2006, a total of 103 genotypes that had shown multiple disease resistance from 2003-2005 against various diseases were also screened under field conditions. The incidence of aflaroot and collar rot was below 6% with majority having zero incidences. The percent incidence of stem rot was between 0.0-58.44%, however, the susceptible check, GG 2C recorded 8.35% incidence. The severity of foliar diseases *viz.,* early leaf spot (ELS), late leaf spot (LLS) and rust were in the range of 1.5 -6.17, 1.2- 5.2 and 1.0, respectively on 1-9 scale.

The data for promising genotypes among the 103 genotypes screened are presented in Table 1b. Fifteen genotypes, which showed resistance both against ELS and LLS were NRCG CS nos.' 19, 25, 35, 36, 72, 79, 137, 144, 156, 158, 159, 192, 196, 222 and 223 recording ≤ 2.0 disease severity on 1-9 scale as against 2.33 and 1.8 in susceptible check GG 20 for ELS and LLS, respectively (however the highest severity of ELS and LLS was 6.17 and 5.2 in the genotype PBS 30044 and NRCG CS 187, respectively).

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Table 1b. Promising genotypes among those which showed resistance during 2003-05 under field conditions and further screened during rainy season of 2006

Sr. No.	Genotype	Disease intensity (1-9 scale**)	
		ELS	LLS
1.	NRCG CS 19	1.67	1.5
2.	NRCG CS 25	1.83	1.5
3.	NRCG CS 35	1.83	1.7
4.	NRCG CS 36	2.00	1.7
5.	NRCG CS 72	1.83	1.7
6.	NRCG CS 79	2.00	1.8
7.	NRCG CS 137	1.83	1.5
8.	NRCG CS 144	1.83	1.3
9.	NRCG CS 156	1.67	1.3
10.	NRCG CS 158	2.00	1.3
11.	NRCG CS 159	1.67	1.5
12.	NRCG CS 192	2.00	1.8
13.	NRCG CS 196	2.00	1.8
14.	NRCG CS 222	1.67	1.3
15.	NRCG CS 223	1.50	1.2
16.	GG 20*	2.33	1.8

*Susceptible check; no. of genotypes screened: 102; ** Highest severity to ELS and LLS was 6.17 and 5.20 in the genotype PBS 30044 and NRCG CS 187, respectively.

Besides this, during *kharif* 2006, 200 breeding lines from Cytogenetics Section were evaluated in sick plot conditions against stem rot (*S. rolfsii*). However, due to continuous rain the inoculum couldn't be added in time and since there was water logging in the field and pathogen being aerobic, disease development was quite low. The disease incidence of stem rot in susceptible check, GG 20 was 6.67% and in majority of the genotypes there was no infection, though the highest incidence was up to 33% in few genotypes. Hence, no valid inference could be drawn regarding resistance of these lines.

A total of 20 genotypes including susceptible and resistant checks were screened against collar rot (*A. niger*) and stem rot (*S. rolfsii*) pathogens under artificially inoculated sick soil condition in concrete blocks during rainy season of 2006. The disease incidence of collar rot and stem rot in susceptible check was 5% and 4%, respectively hence, no valid conclusion could be made about resistant reaction of genotypes screened. Also, a total of thirty advanced breeding lines along with susceptible (GG 2) and resistant check (J 11) were screened for resistance against *A. niger* under laboratory condition adopting dry seed resistance technique. Out of these lines two *viz.*, NRCG CS 168 and NRCG CS 25 showed moderate level of resistance recording below 30% seed colonization as against 100% in some genotypes and 83.3% in GG 2.

Evaluation of *Trichoderma* spp. for bio-control efficacy against collar rot and stem rot pathogens under laboratory conditions

Antagonistic activity of 41 new isolates of *Trichoderma* spp. were studied under *in-vitro* conditions (bangle method) against collar rot (*A. niger*) and stem rot (*S. rolfsii*) pathogens for their antagonistic potential. Colony diameter of *A. niger* and *S. rolfsii* were recorded after 48 and 72 hrs of inoculation. The other parameters *viz.*, time taken to overgrow the pathogen, sporulation and pigmentation of media after growth was considered for assessing antagonistic potential of different isolates of *Trichoderma* spp.

Out of these isolates, seven isolates *viz.*, NRCG T 03, NRCG T 06, NRCG T 12, NRCG T 17, NRCG T 20, NRCG T 27 and NRCG T 29 were found to be highly antagonistic against *A. niger* showing 60-70 % inhibition of growth and completely or partially overgrew the pathogen in 6 days and nine isolates *viz.*, NRCG T 06, NRCG T 11, NRCG T 13, NRCG T 15, NRCG T 17, NRCG T 18, NRCG T 19, NRCG T 32 and NRCG T 41 showed promising antagonistic activity (67-82% inhibition and partially or fully overgrown the pathogen) against *Sclerotium rolfsii*. The isolates NRCG T 06 and NRCG T 17 were effective against both the pathogens.

Integrated disease management (IDM)

A field trial in RBD with 3 replications and 11 treatments was conducted during *kharif* 2006. Observations on major foliar fungal diseases *viz.*, ELS, LLS, rust and soil borne diseases *viz.*, collar rot, stem rot and pod rot were recorded. The cultivar used in the experiment was GG 2. The various components of IDM were seed treatment with *Trichoderma harzianum* @ 4 g/kg seed, intercropping with maize (3:1 ratio), application of gypsum @ 500 kg/ha at flowering stage, foliar spray of 5% turmeric powder, foliar application of Chlorothalonil 0.2% and their combinations.

However, due to high rainfall there was continuous water logging in the field at critical stages of infection by the pathogen and the disease pressure was very low both for soil borne and foliar diseases. As also, various treatments could not be imposed in time due to non-congenial conditions in the field. The maximum disease intensity of ELS and LLS were 2.89 and 2.44, respectively on 1-9 scale and that of collar rot, stem rot and pod rot were 0.31, 5.95 and 7.67%, respectively. Rust did not appear in any of the treatments. The data revealed that differences among treatments were non significant.

Biological control of major fungal foliar and soil borne diseases under field condition

A field experiment was conducted during *kharif* 2006 to see the effect of seed treatment and soil application of *Trichoderma harzianum* and foliar application of culture filtrate of *Verticillium lecanii, Trichoderma* sp. and aqueous leaf extract of neem on soil borne and foliar fungal diseases. However, due to continuous water logging in the field the disease development for soil borne pathogens were negligible as these pathogens are aerobic in nature. Also, the foliar treatments in crop could not be imposed in time due to non-congenial conditions in the field. The maximum incidence of collar rot, stem rot and pod rot were 0.28, 6.66 and 6.0%. The foliar disease pressure was quite low for ELS (<2.67) and LLS (<2.0) on 1-9 scale and rust was absent. The differences among the treatments were found to be non-significant.

Effect of organic soil amendments on incidence of soil borne diseases

A field trial in RBD with three replications and ten treatments with susceptible cultivar GG 20, was conducted during the rainy season of 2006 to study the effect of soil application of fresh leaves of karanj (*Pongamia pinnata*), banyan, *Eucalyptus* @ 500 kg/ha and application of bajra flour (120 Kg/ha), castor cake (500 kg/ha), cotton seed cake (500 kg/ha), gypsum (500 kg/ha) and lime @ 100 kg/ha in furrow at the time of sowing for the management of stem rot. The field was inoculated with the inoculum of *A. niger* at the time of sowing and with *S. rolfsii* after 21 days of sowing. Also, the effects of application of elemental sulphur @ 20 kg/ha were studied for the management of stem rot. However, due to continuous water logging in the field the disease development for soil borne pathogens were negligible. The maximum disease incidence of collar rot, stem rot and pod rot observed were 0.89, 4.15 and 5.33%, respectively. The differences among the treatments were found non-significant.

Effect of foliar application of plant and animal products on disease intensity of major foliar fungal diseases

A field experiment in RBD was conducted during *kharif* 2006 to see the effect of foliar application of some plant products like aqueous extract of turmeric, garlic, *Euphorbia* leaves and neem seed kernels as well as some animal products like cow urine, cow dung, cow milk and curd and their combinations on severity of major foliar fungal diseases. However, the various foliar treatments in crop could not be imposed in time due to non-congenial conditions in the field. The foliar diseases pressure was quite low for ELS (<2.89) and LLS (<2.44) on 1-9 scale and rust was absent. The differences among the treatments were found to be non-significant.

PROJECT 03: PHYSIOLOGICAL STUDIES ON ENVIRONMENTAL STRESSES IN GROUNDNUT

(P. C. NAUTIYAL, J. B. MISRA AND RADHAKRISHNAN T.)

Selection for WUE

To increase crop productivity per unit quantity of water, a better understanding of cultivars and crop water use efficiency is required. The challenge is to manage the crop or improve its genetic makeup to enable it capture more and more of the water supplied for use in transpiration (T); exchange transpired water for CO_2 (Carbon Exchange Rate) more effectively for producing biomass; and convert a greater extent of biomass into kernels i.e. to improve the harvest index (HI). With these objectives, about 180 promising lines developed in 'ACIAR-ICAR-ICRISAT collaborative project on selection for WUE' were revisited for their suitability for cultivation in rain-dependent system. The specific leaf area (SLA), HI and total pod yield in *kharif* and summer seasons were recorded (Table 1) and then five lines *viz.*, ICR 3, ICR 4, TIR 17, JAL 42 and JUG 16 were selected. Pod yields of genotypes varied with seasons and in general were higher in summer, but all the five selected genotypes gave much higher yield than the local check variety GG 2 in both the seasons.

Table 1. Performance of advanced breeding material at Junagadh in *kharif* and summer seasons

Genotype	SLA (cm^2/g)	Shelling turnover (%)	100-seed mass (g)	Harvest index	Pod yield (kg/ha)
Kharif					
ICR 3	164	66	48	0.29	1950
ICR 4	164	65	44	0.36	1620
JUG 16	158	60	39	0.30	2690
TIR 17	133	67	35	0.42	1270
JAL 42	159	66	41	0.45	2000
GG 2 (local check)	155	67	42	0.20	920
Summer					
ICR 3	150	72	51	0.31	2560
ICR 4	143	68	47	0.36	3500
JUG 16	160	71	43	0.31	3160
TIR 17	132	71	36	0.42	3360
JAL 42	156	59	41	0.44	3120
GG 2 (local check)	151	69	34	0.22	2010

Evaluation of wild *Arachis* species for tolerance of abiotic stresses

Low and high temperatures and leaf water relations

The Indian groundnut cultivars have a narrow genetic base. Hence, it was of interest to investigate the genetic variability among wild *Arachis* species and their accessions for tolerance to thermal stress and leaf water relations. A wide variation was observed in leaf morphological characters such as colour, shape, hairiness, length and width, and thickness (measured as SLA). The temperature and time required for 50% leaf injury was worked out with limited number of genotypes and was found to be 54°C for 50 minutes. Among 36 genotypes (having SLA in the range of 66 and 161 $cm^2 g^{-1}$) screened, the inherent potential for cold as well as heat tolerance in terms of relative leaf injury (RI) was observed. Correlation between SLA and RI values for heat ($r = 0.38$, $P < 0.05$) and cold ($r = 0.52$, $P < 0.05$) tolerance was positive, indicating that thicker the leaf the lower the injury or the higher the tolerance.

Among 6 species and 13 accessions, comprising both heat-tolerant and heat- susceptible genotypes, the concentrations of various leaf chemical constituents such as total protein, phenols, sugars, reducing sugar, amino acids, proline, epicuticular wax load and chlorophyll varied significantly. The epicuticular wax load ranged between 1.1 and 2.5 mg dm^{-2} among 13 *A. glabrata* accessions. These accessions were categorized into two groups *i.e.* high-wax (range: 2.0 to 2.5 mg dm^{-2}) and low-wax types (range: 1.1 to 1.6 $\mu g\ dm^{-2}$). The high-wax types showed a higher diffusion resistance (*dr*) compared to low wax types; though the transpiration rate (*tr*) in high-wax type was moderate (between 9.5 and 11.6 ìg $cm^{-2}s^{-1}$). Genetic variability in parameters such as canopy temperature, *dr* and *tr* was also distinct. The fully turgid leaves with relative water content (RWC) ≥91%, showed leaf water potential (Ψ_{leaf}) between -0.7 and -1.2 MPa. Results indicated that the plants with thicker leaves are better protected from heat injuries. Further, epicuticular wax load seems to help in maintaining stomatal regulation and leaf water relations, thus affording adaptation to wild *Arachis* species to thrive under water-limited environments. The sources of tolerance, as identified in this study, could be utilized to improve thermal tolerance of the groundnut cultivars by intra-specific hybridization, either by conventional breeding and using embryo rescue techniques, if required, or utilizing biotechnological tools.

Variation in response to salinity during seed germination and early seedling growth

The increase in EC of underground water with passage of time is making it unsuitable for irrigation. Moreover, salinity tolerance during germination stage is critical for survival and growth of crop under saline soils or salinity originated from saline-water irrigation. The objective of this study was to evaluate groundnut cultivars for sensitivity to salinity during germination and early seedling stage. Experiment was conducted with 27 groundnut cultivars belonging to *Spanish* and *Valencia* groups. Sea water of different concentrations was prepared by mixing it with tap water; which constituted treatments: T_1 = 20% sea water and 80% tap water (EC 10 m mhos cm^{-1}), T_2 = 40% sea water and 60% tap water (EC 18 m mhos cm^{-1}), T_3 = 60% sea water and 40% tap water (EC 25 m mhos cm^{-1}), T_4 = 80% sea water and 20% tap water (EC 31m mhos cm^{-1}). A control was maintained by using tap water (EC 1.0 m mhos cm^{-1}).

Wide genotypic differences were observed in several parameters (germination, SVI, and seed vigour) under the highest salinity *i.e.* T_4. Based on salinity tolerance index (STI), the salinity-tolerant and salinity-susceptible lines were identified. Various interactions between the levels of salinity and the cultivars were significant, for example, germination in control was 95% while it was only 36% in T_4. Similarly, among the cultivars, the tolerant ones showed >70% germination in T_4, while in case of susceptible ones the germination was completely inhibited. Cultivars Kopergaon 3, MH 2, Gangapuri, Tirupati 4, ICGV 86590 and GG 4 showed >70% germination in T_4, but cultivars TMV 12, ICGS 44 and VRI 4 showed about 44% reduction in germination and this salinity level was considered as 50% lethal dose (LD_{50}) for these cultivars and became a demarcation line between the tolerant and susceptible ones.

Thus, high salinity was found to be more detrimental to the growth of secondary roots than to any other parameter studied in this experiment. On the basis of the number of secondary roots the cultivars Kopergaon 3, MH 2, Gangapuri, VRI 4, and MH 4 were found to be relatively tolerant, whereas cultivars CO 3, ICG (FDRS) 10, Tirupati 4, GG 3, and VG 9521 were found to be susceptible. All the parameters of vigour such as germination rate, germination speed, germination capacity, standard germination and coefficient of velocity of germination were adversely affected with increasing levels of salinity. Thus the genetic potential of tolerance of salinity during germination and early seedling stage in cultivars Kopergaon 3, GG 4, MH 2, ICGV 86590, Gangapuri, and ICGS 44 could be utilized either by directly cultivating tolerant genotypes in the problem areas or by using as parents for further improving the tolerance level by conventional breeding methods alone or in combination with the modern bio-technological tools.

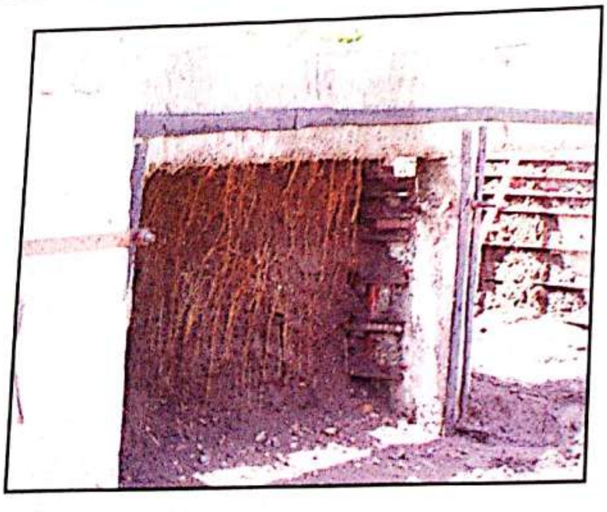
Development of ideotype concept in groundnut

Considering the importance of ideotype for efforts aimed at increasing productivity in groundnut under rain-dependent system, a project was completed between 1987 and 1990 under Micromission-I of TMOP. As the duration of the project to work on ideotype was too short; only limited work could be conducted on plant growth analysis. Work is now being focused on crop canopy and root architecture suitable for rain-dependent system.

Groundnut leaf is pinnately compound and shows changes in leaf angles between stem and leaf, and between petiole and leaflet under water-deficit conditions and during different hours of the day. Genetic variation in their response to the leaf angles of some of the cultivars was observed (Table 2). Little information is available on root architecture and growth under water-deficit conditions. Therefore studies on root architecture under normal and a water-deficit condition were initiated (Figure 1). After taking out the complete and whole root system of individual plant from root blocks, plant samples were brought to the laboratory and observations on various parameters were recorded. The study conducted, so far, showed that a penetrating and efficient root system exists in cultivars, TAG 24, ICGS 44, ICGV 86031, JL 24 and Gangapuri. However, root characteristics related with drought tolerance are yet to be identified. The major areas of focus on "Ideotype" will be plant growth and development, crop canopy architecture, root architecture and seed and seedling vigour

Table 2. Genetic variations in leaf and leaf-let angles in five groundnut cultivars

Genotype	Leaf angle with main axis	Leaflet angle with petiole	Angle between two lower leaflets	Angle between two upper leaflets
GG 20	54°	15°	37°	121°
CSMG 84-1	49°	19°	48°	129°
M 13	60°	18°	68°	158°
ICGS 44	60°	14°	60°	150°
MH 2	53°	36°	87°	148°



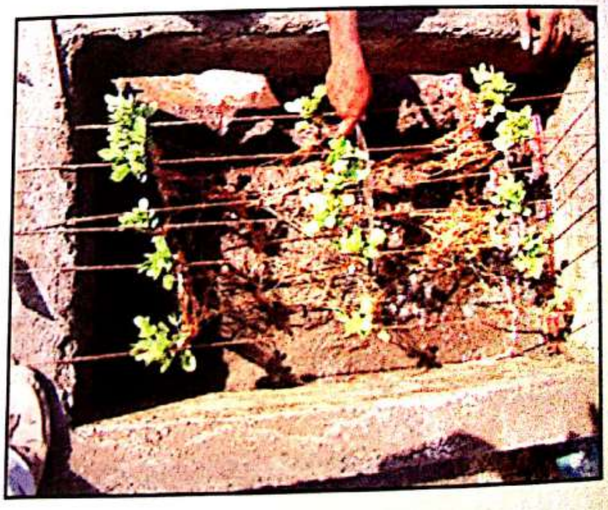


Figure 1. Concrete blocks for studies on roots of groundnut (side and top views)

PROJECT 04: INTEGRATED NUTRIENT MANAGEMENT IN GROUNDNUT

(K. K. PAL, A. L. SINGH AND R. DEY)

Sub-project 1: Development of biofertilizer packages for groundnut

(K. K. Pal and R. Dey)

Plant Growth Promoting Rhizobacteria (PGPR)

Effect of consortia of PSM, groundnut-rhizobia and PGPR on growth and yield of groundnut

Several plant growth-promoting rhizobacteria (PGPR), phosphate solubilizing bacteria (PSM), and groundnut-rhizobia were tested within the group and in various combinations for compatibility. The PGPR, PSM, and Rhizobium have been referred to as A, B, and C, respectively, hereafter. On the basis of compatibility tests, seven combinations of consortia were constituted and then evaluated in pot and field trials.

In a pot trial conducted during the summer 2006, inoculation of seed with the different consortia had more or less similar beneficial effects on the growth of groundnut plants. Inoculation with mixtures of PGPR with PSM or *Rhizobium* or all the three had better effects than their inoculation individually. There was significant increase in the pod yield of groundnut upon inoculation in most of the treatments. The maximum increase was obtained with consortium BC. This treatment also recorded maximum root and nodule mass.

Inoculation of seed with different consortia of bacterial cultures resulted in significant improvement in growth, nodulation and yield in groundnut cultivar GG 2, during a field trial in summer 2006. In terms of pod yield, only two consortia, AC and ABC, resulted in significant enhancement of yield, 18% and 12%, respectively, as compared to un-inoculated control. The best consortium AC also resulted in significant enhancement of hundred kernel mass (HKW).

Population of the individual members of the consortia was determined in the rhizosphere on the basis of intrinsic antibiotic resistance patterns. In case of PGPR consortium, the population of *Pseudomonas* spp. increased in the rhizosphere from 30 DAS to 60 DAS, irrespective of combinations. Similar trend was also noticed in case of PSM strains. In dual inoculation of two consortia, however, population of individual strain sometimes decreased. In case of rhizobia, co-inoculation either with PSM or PGPR improved nodule occupancy.

During the *kharif* 2006, most of the consortia had significantly beneficial effects on the various parameters tested. However, the average yield of GG 2 cultivar was very low due to excessive rains and waterlogged conditions during *kharif* 2006. The average pod yield in different treatments ranged from 131 to 205 kg/ha. For pod yield, however, the best result was obtained with consortium C comprising two *Rhizobium* strains.

Effect of PGPR on the growth and yield of bold seeded groundnut

A field trial was conducted during the *kharif* 2006 to study the effect of inoculation of PGPR on the growth and yield of bold-seeded groundnut varieties. Five bold seeded varieties, namely BAU 13, B 95, M13, Somnath and TKG 19A and three PGPR cultures, namely PGPR1, PGPR2 and PGPR4 were selected for this study. The average yield of the varieties was very low due to excessive rains and waterlogged conditions in the season. The yield of TKG 19A was the maximum (498 kg/ha) when inoculated with PGPR1. In general, inoculation with PGPR cultures resulted in increase in root length, shoot length, haulm yield, shelling turnover and hundred kernel mass. Both the crop growth and pod yield were severely affected due to constant water logging in the fields and lack of sunshine.

The bold-seeded varieties differed with each other for the parameters tested. The maximum pod yield was obtained with variety TKG 19A which was followed by M 13. The varieties Somnath, BAU 13, and B 95 yielded at par. The highest haulm yield was obtained in BAU 13 followed by B 95. The maximum shelling outturn was obtained in M 13 and hundred kernel mass in TKG 19A.

Groundnut rhizobia

Effect of competitive strains of groundnut-rhizobia on the growth and yield of groundnut under irrigated conditions

Two newly identified strains of groundnut-rhizobia *viz.*, NRCG 4 and NRCG 9 were evaluated for nodulation and effect on growth parameters of groundnut cultivar GG 2 under field conditions along with three reference strains NC 92, IGR 6 and IGR 40, during summer of 2006. Seed bacterization of groundnut cultivar GG 2 with groundnut rhizobia resulted in marked improvement in shoot and root growth and nodulation. The inoculation resulted in significant increase in pod yield with IGR 6 (19.0%), NRCG 9 (13.6%), NRCG 4 (9.0%), and IGR 40 (6.3%). There was also improvement in shelling turnover, hundred seed mass and haulm yield as due to inoculation with groundnut rhizobia. Inoculation with NRCG 4 resulted in maximum shelling out-turn and 100 seed mass.

Studying the role of groundnut genotypes on rhizodeposition

Two parental lines of groundnut, namely, GG 2 and ICGV 86031 and six progenies of the cross between these two parental lines were taken up to study the role of groundnut genotypes on rhizodeposition. Compared to parental lines, three progenies *viz.*, JUG 22, JUG 24 and JUG 48 were high yielding and the rest of three progenies JUG 43, JUG 46 and JUG 47 were low yielding. It was hypothesized that through breeding process it is possibl to enhance the population of both beneficial and deleterious microorganisms in the rhizosphere vis-à-vis yiel enhancement or reduction coupled with enhancement or impairment of nutrient uptake. Population dynamics o different representative groups of microorganisms in the rhizosphere of the varieties and the advanced breedin lines indicated that, when sampled at 7 day intervals, starting 7 days after emergence, the population o cyanogenic fluorescent pseudomonads increased in lines, which produced significantly low yield than th parental lines GG 2 and ICGV 86031. The population of cyanogenic fluorescent pseudomonads enhance appreciably over the period of time. The population of free-living nitrogen fixers and phosphate solubilize increased in lines, which gave significantly higher pod yield than parental lines.

Table 1. Effect of consortia of PGPR, PSM and rhizobia on yields of pod and haulm and nodulation of cultivar GG 2 in summer 2006

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	Nodulation at 45 DAS (no./plant)
Consortium A	2062	3620	15.1
Consortium B	2166	3800	17.0
Consortium C	2112	3950	22.3
Consortium AB	2269	4263	33.3
Consotium AC	2413	4090	23.6
Consortium BC	2250	4500	25.6
Consortium ABC	2290	4095	33.1
Control	2045	3587	12.3

Table 2. Effect of competitive strains of rhizobia on the yield and parameters of BNF of cultivar GG 2 grown in summer 2006

Rhizobial strain	Pod yield (kg/ha)	Haulm yield (kg/ha)	Nodulation at 45 DAS (No./plant)	Nodule dry mass at harvest (mg/plant)
IGR 6	2604	3215	33.0	31.0
IGR 40	2326	3042	22.6	28.0
NC 92	2231	3052	22.7	24.9
NRCG 4	2381	3225	32.5	25.8
NRCG 9	2485	3357	29.7	32.5
Control	2187	3020	12.1	23.5

Table 3. Population densities ($x10^4$ CFU/g soil) of pseudomonads in the rhizosphere of groundnut genotypes

Genotype	Fluorescent pseudomonads	Non-fluorescent pseudomonads
JUG 22	3.75	6.0
JUG 48	3.0	32.5
JUG 24	1.50	300.0
JUG 43	5200.0	2300.0
JUG 47	210.0	780.0
JUG 46	185.0	230.0
GG 2	2.05	3.65
ICGV 86031	0.70	3.75

Sub-project 2: Mineral nutrient requirement and their disorders in groundnut

(A. L. Singh)

Ca and P nutrition of groundnut with various pod and seed-sizes

The role of Ca and P in nutrition of pods of various seed sizes of groundnut was studied in a field experiment. Forty groundnut genotypes with varying pod structure and sizes (length 1.64-4.7 cm, width 0.74-1.68 cm), and the seed sizes (length 0.5-1.8 cm, width 0.3-0.97 cm) were grown in field with two doses of P (0 and 50 kg/ha) and one dose of Ca (100 kg/ha).

The P and Ca nutrition increased the number of pods and pegs, yields of pod and haulm, and length and width of the pods and seeds in most of the genotypes excepting a few small seeded genotypes. The larger the pod and seed size the greater was the response of these elements, which perhaps was due to a larger surface area for nutrient absorption by pods in the soil. Interestingly, the high yielding genotypes were generally having large to medium pod and seed sizes.

The large pod size genotypes, showed a higher P in their kernel and shell than that in the small pod size genotypes. Application of calcium increased the Ca content of kernel and shell in various groundnut genotypes with a more pronounced effect on large seeded ones.

Screening for K- and S-efficient genotypes

Screening of 103 groundnut genotypes comprising released cultivars and nutrient efficient lines was carried out in field for identifying K- and S-efficient genotypes by growing them under unfertilized and fertilized conditions (control, 50 kg K/ha and 20 kg S/ha). On the basis of the relative performance, the nutrient efficient and inefficient groundnut genotypes were identified.

- K-efficient: LGN 2, ICGV 88448, Tirupati 3, TKG 19 A, ICGV 86590, NRCG 1308, ICGS 76, CSMG 884, M 335, NRCG 7085-1
- K-inefficient: ICGS 5, GG 6, GG 7, Tirupati 4, Chico
- S-efficient: ICGV 86590, LGN 2, M 335, TG 64, FeESG 10-1, CSMG 884, B 95, Somnath, BAU 19, TKG 19A
- S-inefficient: Gangapuri, ICGS 5, MH 2, Tirupati 4, Chico

Studies on Mo and B nutrition in groundnut

In micro-plots response of various B and Mo levels was studied in four popular cultivars namely, GG 2, JL 24, ICGS 76 and GG 20. The study revealed that for the cultivars GG 2, GG 20 and JL 24; 0.4 ppm of B was sufficient, but for cultivar ICGS 76, 0.6 ppm of B was essential to meet their respective requirements. In case of Mo, the groundnut cultivars JL 24, GG 2 and GG 20, showed higher requirements and response was observed up to 0.8 ppm, but in case of ICGS 76 only up to 0.4 ppm.

In general, the old groundnut cultivars JL 24 and GG 2, showed a low requirement of both Mo and B, whereas the relatively new cultivars ICGS 76 and GG 20 had a high requirement of both the elements. It was observed that soil application of B @ 1 kg/ha was essential to meet the requirement of this nutrient.

Screening core germplasm for fertilizer response and high nutrient density

Core germplasm collection comprising 194 accessions was evaluated under unfertilized and fertilized (with NPK) conditions and the kernels thus produced were analysed for Ca and micronutrient densities (contents). The data on pod yield revealed that the high yielding genotypes NRCG 11711, 11942, 11693, 1913, 6064, 12272, 10911, 10496, 3198 and 11866 were more fertilizer responsive (with more than 200 g pod/m^2) compared to low yielding genotypes NRCG 12605, 11996, 168, 7306, 12329, 12881, 12879, 11701, 11868 and RCG 12748 which were less fertilizer responsive (< 60 g pod/m^2).

Some of the genotypes having high nutrient density in their kernel were:

- High Fe: NRCG 12291, 12148, 11088 12880, and 11236 (above 500 ppm)
- High Mn: NRCG 11126, 12291, 3533, 10820, and 12321 (above 40 ppm)
- High Zn: NRCG 11868, 3648, 12321, 1086, and 11925 (above 50 ppm)
- High Cu: NRCG 12746, 9966, 10820, 11088, and 11276 (above 14 ppm)
- High Ca: NRCG 11651, 5360, 12319, 12713, 12393, 7443, 12339, 6811, and 8956

Screening groundnut for high kernel Zn content

The kernels of 70 groundnut genotypes were analyzed for Zn as well as Fe, Mn, Cu, Ca and P and were categorized as low- (below 30 mg kg^{-1}), medium- (31-50 mg kg^{-1}) and high- (51 mg kg^{-1} and above) zinc density genotypes.

The Zn concentration in seed of various groundnut genotypes ranged from 11 to 77 mg kg^{-1} with a mean value of 45 mg kg^{-1} and thus 7 genotypes were identified as low, 34 as medium and 19 as high density genotypes.

The seeds of most of the high Zn containing genotypes were also rich in P, Ca and Fe. The yield of these genotypes was in the range of 857-1527 kg ha^{-1}. Of these, GG 5 and ICGV 86590 are commercial groundnut

Inter-institutional collaborative trials

For identifying nutrient efficient genotypes for economizing of fertilizer application a multi-location trial with 100 genotypes was laid out at Mainpuri, Vriddhachalam, Coimbatore and Raichur where P and Ca deficiencies are known to occur. These genotypes were grown under unfertilized and fertilized (with P and Ca) conditions and data on growth and yield were recorded. The data of these centers indicated that most of the nutrient efficient groundnut genotypes identified earlier showed a better response at all the locations indicating their inbuilt efficiency.

The yields of top five P-and Ca-efficient genotypes with and without P or Ca fertilizers are given below:

Yield of P-efficient genotypes

Mainpuri			Vriddhachalam			Raichur			Coimbatore		
Genotype	PY (kg/ha)		Genotype	PY (kg/ha)		Genotype	PY (kg/ha)		Genotype	PY (kg/ha)	
	C	P		C	P		C	WIP		C	WIP
Chitra	1648	1988	ICGS 76	3902	5498	R2001-3	806	907	ALR1	112	246
CSMG 884	1640	1868	SG 84	2234	5440	R 2001-2	729	745	FeESG 10	310	240
CSMG 84-1	1348	1776	HNG 10	2286	5029	DSG	1551	664	DH 8	536	235
M 335	1732	1752	K 134	2269	4750	R 8808	613	643	TG 32	135	229
LGN 2	1520	1628	M 527	2397	4729	M 335	574	606	FeESG 8	531	217

PY= pod yield; C = control; P= with phosphorus application

Yield of Ca-efficient genotypes

Mainpuri			Vriddhachalam			Raichur			Coimbatore		
Genotype	PY (kg/ha)		Genotype	PY (kg/ha)		Genot-ype	PY (kg/ha)		Genotype	Pod yield (g/5m row)	
	C	Ca		C	Ca		C	Ca		C	Ca
CSMG 884	1640	2256	GG 13	1664	4754	R2001-3	806	868	Spanish Improved	166	479
CSMG 84-1	1348	1996	ICGV 86325	3596	4611	R2001-2	729	764	CO-1	79	415
M 335	1732	1928	VRI2	3438	4444	S-230	604	662	ICGV 86590	259	389
Chitra	1648	1840	DSG 1	2176	4278	DSG 1	551	630	GG 7	140	384
LGN 2	1520	1716	Jawan	2147	4168	RS-1	593	606	FeESG 8	531	377

PY= pod yield; C = control; P= with calcium application

Based on the data of four locations, the following nutrient efficient lines were identified:

- P-efficient: ICGV 86590, FeESG 8, CSMG 84-1, SG 84, ICGS 76
- Ca-efficient: CSMG 84-1, M 335, ICGV 86590, DSG 1, GG 7, GG 13

Further, the study was conducted for three consecutive seasons at Vriddhachalam and following results were obtained.

Efficient genotypes for Ca and P uptake

P and Ca efficient	P efficient	Ca efficient
TMV 2, S 230, R 8808, NRCG 3498, Kadiri 4, Tirupati 1, ALR 3, TG 32, Spanish Improved, AK12-24	Jyoti, CSMG 84, TNAU 256, CO 1, GG 12, ICGS 11, Punjab 1, TAG 24, ALR 1, VRI 3, K134, CSMG 84-1	Jawan, VRI 3, GG 13, NRCG 7472, MH 1, S 206, RG 141, Tirupathi 4, Tirupathi 2, CSMG 884, DRG 17, TG 3, NRCG 47, TG 26, TG 22 M335 and Gangapuri

Screening, maintenance and multiplication of nutrient-efficient and inefficient lines

One hundred ten nutrient-efficient and in-efficient groundnut genotypes were grown for maintaining their seed stocks for various experiments including their evaluation in the NEH region.

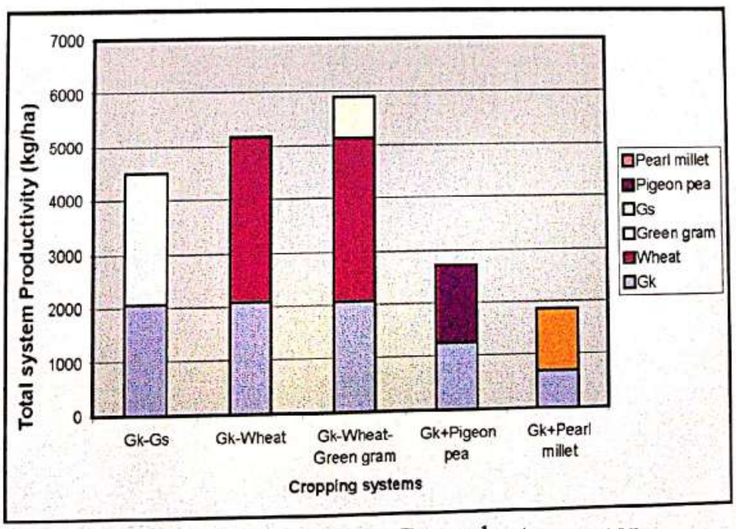
PROJECT 05: STUDIES ON GROUNDNUT BASED CROPPING SYSTEM

(DEVI DAYAL, I. K. GIRDHAR, P. C. NAUTIYAL AND K. K. PAL)

Long- term experiment on nutrient dynamics in groundnut based cropping systems

A long-term experiment with five popular groundnut based cropping system *viz.*, sole groundnut cropping system, two intercropping systems (Groundnut + pearl millet and groundnut + pigeon pea) and two sequential cropping systems (groundnut-wheat and groundnut-wheat-green gram) were initiated during *kharif* 1998 with various combinations of organic and inorganic fertilizer regimes to study the nutrient dynamics and sustainability of the systems. Groundnut-summer groundnut system was included in the study in the year 2005. After nine years, the following changes in yield of groundnut and soil properties were observed:

- Under intensive cropping system with 200-300% cropping intensity, a maximum Groundnut Equivalent Yield (GEY) of 3865 kg/ha was recorded under groundnut- wheat-green gram followed by GEY of 3401 kg/ha under groundnut-groundnut system during 2006-07.
- Grain yield of wheat was significantly low (3433 kg/ha) under the reduced dose of fertilizers (50% RDF) compared to that of under 100% RDF (3516 kg/ha) there by indicating that there was no scope for reducing the nutrient dose even if FYM was applied @ 5 t/ha to *kharif* groundnut.
- In groundnut-wheat-green gram rotation, in wheat with 50% RDF + FYM @ 5 t/ha, the grain yield was statistically at par (3693 kg/ha) with that recorded under the RDF treatment (3695 kg/ha).
- The grain yield of green gram was 620-725 kg/ha. The residual effect of FYM applied in *kharif* groundnut was evident and the grain yield improved by 12.4% over the yield without FYM treatment.
- The green gram crop residue of 667-960 kg/ha, after picking of pods, was incorporated into the soil that helped to improve physical and biological properties of the soil.
- Summer groundnut yielded 2297 and 2598 kg/ha under RDF and FYM treatment respectively, indicating 13.1% increase in yield due to residual effect of FYM.
- High rainfall especially during pod development stage reduced the *kharif* groundnut yield drastically to as low as 165-699 kg/ha.
- The maximum *kharif* groundnut yield (616 kg/ha) was recorded in groundnut-wheat-green gram cropping system, followed by that of groundnut-wheat (573 kg/ha) system.



Gk = Groundnut-*kharif*; Gs = Groundnut-summer

Figure 1. Total system productivity of various groundnut based cropping systems

Table 1. Effect of cropping systems on total nitrogen, organic carbon, pH and EC of soil

Treatment	Total N (ppm)	Organic C (%)	pH	EC (dS m^{-1})
Sole Groundnut	32.14	0.487	8.07	0.152
Groundnut-Wheat	31.67	0.480	8.03	0.161
Groundnut-Wheat-Green gram	32.16	0.489	8.09	0.177
Groundnut+Pigeon pea	31.65	0.444	7.90	0.158
Groundnut+Pearl millet	30.94	0.462	7.97	0.147

The total productivity (kg/ha) and total soil nitrogen (ppm) and soil organic carbon (%) contents were highest in groundnut-wheat-green gram sequential cropping system during the cropping year 2006-07, whereas the soil pH and EC (dSm^{-1}) decreased in the groundnut + pearl millet intercropping system.

Enhancing groundnut crop water productivity through irrigation scheduling

The studies indicated that there was a possibility to reduce irrigation demand during vegetative and pod maturity stages. Irrigation depth can also be reduced if irrigation is applied as per ET demand. Hence, irrigations were scheduled (6-10) as per ET demand by skipping less sensitive stages. The results indicated that:

- The ET varied from 230 mm to 530 mm under different treatments during the cropping season.
- The maximum ET of 12-15 mm/day was recorded at pod development stage (55-70 days after sowing) of groundnut
- Irrigation scheduling at 0.80 PE gave almost similar yield with that under 1.00 PE resulting in net saving of irrigation water by 20%. However, further reduction in irrigation depth reduced the yield significantly.
- The pod yield was not affected significantly due to moisture deficit stress during vegetative phase up to 66% of moisture deficit of field capacity (25-28 days) and during pod maturity up to 75% of moisture deficit of field capacity (15-18 days).
- The pod yield was maximum (3282 kg/ha) with 9 irrigations at 0.80 PE and providing stress at vegetative stage.
- Under limited availability of water, irrigation can be scheduled with 7 irrigations at 0.80 PE, skipping irrigation at vegetative and pod maturity (90-100 days) stages , with a water productivity of 7.76-7.81 kg/mm/ha.

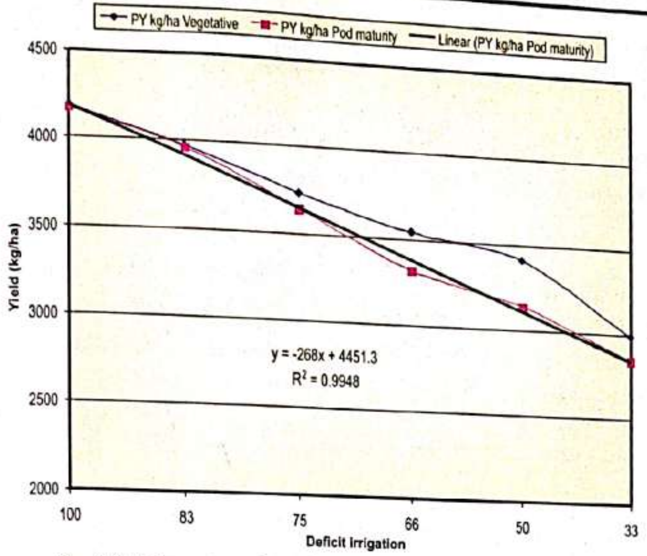


Figure 2: Yield water function under two different stages

Yield-water functions influenced by nutrients in groundnut

The studies revealed that relationship of evapo-transpiration (ET) with pod yield of groundnut was linear but the degree of relationship varied with the genotypes. The sensitive cultivar (TG 26) had higher values of regression coefficient at reduced soil water content than that of tolerant cultivar (TAG 24). The effect of nutrients especially potassium and calcium was studied on WUE and the yield of groundnut under varied moisture regimes. The results are briefly mentioned below:

- Increasing the degree of moisture stress reduced the pod yield significantly. However, as degree of stress increased, the reduction in yield was less under potassium (42.3%) and calcium + potassium (49.9%) than that under the control (40.6%), in which only nitrogen and phosphorus were applied.
- Application of Ca without correcting K balance yielded significantly less under stress condition.
- Water use efficiency showed sigmoid curve with increasing degree of moisture stress (highest 7.45 kg/mm/ha under 60% deficit of FC).

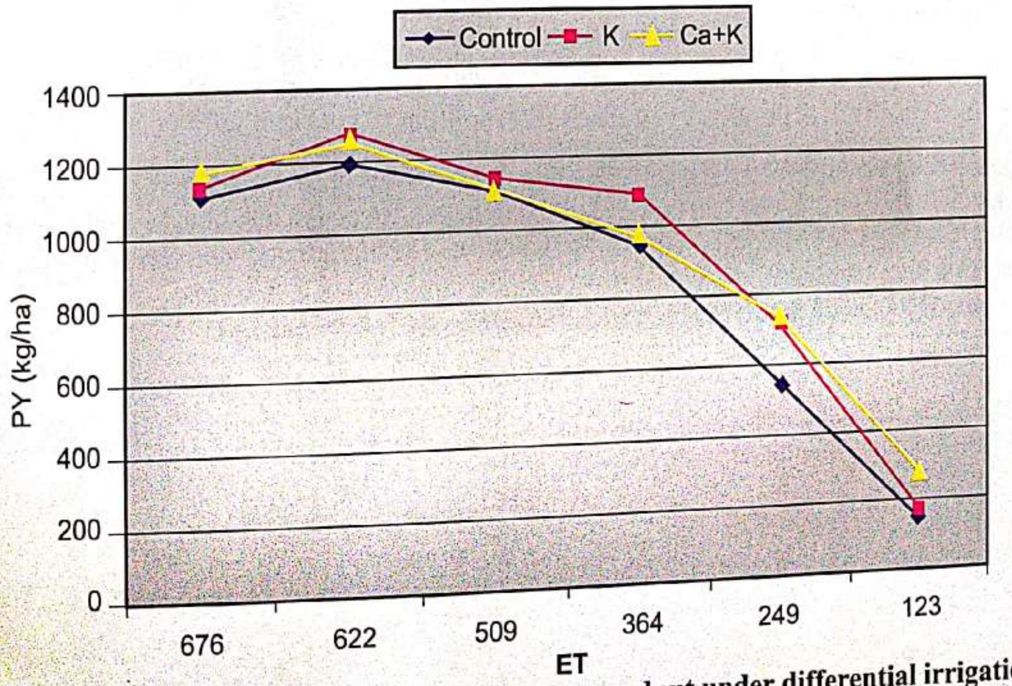


Figure 3: Effect of K and Ca on pod yield of groundnut under differential irrigation

- Application of Ca without correcting K balance did not improve WUE. However, application of both Ca and K significantly improved WUE and was the maximum (7.116 kg/ha/mm) under 60% deficit of FC
- The Ratio of Ca with K seemed to be an important factor for achieving higher yield and better water productivity in irrigated groundnut.

Dry seeding of groundnut under rainfed condition

This experiment was conducted during *kharif* 2006. Various chemicals/materials were coated on seeds before sowing. The treated seeds were then sown under dry conditions about 15 days before and about 5 days before the expected date of onset of monsoon (25[th] June). The normal sowing after onset of monsoon was done on 28[th] June. The results are briefly summarized below:

- The dry sown seeds germinated 4-6 days earlier than those which were sown after the onset of monsoon.
- The pod yield was the highest when sowing coincided with the onset of monsoon. Among different treatments, seed coating with $CaSO_4$ and cow dung showed some potential.

Table 2. Effect of different seed coatings and dates of sowing on pod yield (kg/ha) of *kharif* groundnut

Treatment	Date of sowing		
	07/6/2006	20/6/2006	28/6/2006
$CaSO_4$	337	220	348
Rock phosphate	219	453	189
$CaCl_2$	182	71	108
Cow dung	394	625	208
Wheat flour	133	574	94
Clay	206	535	77
Chloropyriphos	328	452	195
Groundnut shell	259	771	77
Pearl millet flour	317	539	176
Control	209	794	84
Average	258.4	503.4	155.6

Genotypic compatibility of groundnut + cotton intercropping

The experiment was conducted during *kharif* 2006. Six varieties of groundnut (M 13, M 335, GG 20, HNG 10, TAG 24 and GPBD 4) were intercropped with six varieties of cotton (Bt, Malika, Myco12, Myco 630, VZ 97 and a local cv. Devraj and sown as per recommended practices. The highest pod yield was recorded in GG 20 both in sole as well as in intercropping (Table 3).

Table 3. Effect of intercropping with cotton on yield of groundnut

Variety	Sole crop Pod yield (kg/ha)	Intercrop Pod yield (kg/ha)
M 13	154	141
M 335	174	143
GG 20	254	209
HNG 10	164	141
TAG 24	61	51
GPBD 4	29	13

PROJECT 06: MANAGEMENT OF EXISTING AND EMERGING PROBLEMS OF SOIL AND WATER SALINITY FOR GROUNDNUT PRODUCTION

(I. K. GIRDHAR, P. C. NAUTIYAL AND K. K. PAL)

Use of saline water in groundnut based cropping system

Consolidated results of five year (2002 to 2006)

In Gujarat, particularly in Saurashtra region, farmers generally raise only one rain-fed crop of groundnut and keep fields fallow in the *rabi* (winter season) as they can not use underground saline water for irrigation on the one hand and non-availability of canal water for irrigation on the other hand. An experiment was started in the year 2002 and continued up to 2007 with the objective of exploring the possibility of using saline ground water for irrigation in different crop rotations (groundnut-groundnut, groundnut-wheat, and groundnut-mustard) instead of taking single crop of groundnut in coastal area of Saurashtra region. On the basis of the results obtained up to *kharif* 2006, it was concluded that the saline water of 2-3 dS/m salinity as supplemental irrigation of *kharif* groundnut, and in *rabi* season, 4-6 dS/m salinity of water can be used for irrigation of wheat and mustard crop for optimum yield (about 1000 kg of groundnut, 1500 kg/ha mustard and 3500 kg/ha of wheat), whereas saline water was suitable for irrigation of summer groundnut because of build up of high soil salinity due to use of saline water for irrigation. The build up salinity in root zone (EC_{iw} = 4 dS/m to groundnut and EC_{iw} 6 dS/m to wheat and mustard) adversely affected absorption of water by plants even though the soil had enough water. This resulted in stunting plants and further significant decrease in yield. Prolonged use of saline water for irrigation increased the soil pH from 7.8 in 2002 to 9.0 in 2006, which also possibly deteriorated the soil health and affected the yield. The oil content in groundnut kernels and mustard seeds also decreased significantly with increase in salinity of the water from 0.5 to 6 dS/m.

Mustard 2006-07

After harvest of *kharif* groundnut in 2006, mustard crop was taken in rotation during November 2006 in the saline black clay soil using saline water of four different salinity levels (0.5, 2, 4 and 6 dS/m). It was observed that the seed yield decreased from 1708 to 1552 kg/ha with an increase in water salinity from 0.5 to 6 dS/m and soil salinity from 1.0 to 5.8 dS/m, respectively. Decrease in yield due to soil salinity of 5.4 dS/m and use of saline water for irrigation upto 4 dS/m salinity over the control was non significant. Differences in other plant characters such as dry matter yield, hundred seed mass, number of branches and pods per plant were also non-significant at the aforesaid levels of soil and water salinity. The yield and yield contributing characters were significantly adversely affected at high water (EC_{iw}=6 dS/m) and soil (EC_e=5.8 dS/m) salinity, yet an economical yield (1552 kg/ha) could be obtained. Yield of oil, however, decreased significantly from 525 to 490 kg/ha with an increase in soil salinity from 1.0 to 5.8 dS/m as a result of saline water irrigation, salinity varying from 0.5 to 6 dS/m. Thus it was observed due to use of saline water for irrigation of mustard crop there was a progressive build up of soil salinity in the root zone with passage of time from sowing to harvest of mustard crop. With the increase in salinity of the irrigation water there extent built up of salinity was also high.

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

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* Inter-Institutional Collaborative project with ICAR Research Complex for NEH region

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[2] ICAR Research Complex for NEH region

Experimentations in North-Eastern Hill regions

Several field experiments were conducted in collaboration with the ICAR Research complex at Barapani and Tura (Meghalaya), Lembucherra (Tripura) and Imphal (Manipur), Jharanapani (Nagaland), Kolasib (Mizoram) and Basar (Arunachal Pradesh) to develop suitable cultivation technologies for popularization of groundnut cultivation in North-Eastern Hills. The findings of the experiments and the sustainable production technologies thus developed are summarized below:

Evaluation of recently released cultivars and nutrient efficient lines

Thirty-six groundnut genotypes comprising recently released cultivars and nutrient efficient genotypes were evaluated in field for their yield and tolerance of toxicities of Al and Fe and deficiencies of Ca and P under rain-fed conditions at Basar (Arunachal Pradesh), Kolasib (Mizoram) and Lembucherra (Tripura). The results on yield and related parameters are given in Table 1 and 2.

At Kolasib in Mizoram, where soil is highly eroded and acidic, several cultivars performed well with a pod yield more than 2000 kg/ha. Of these, three cultivars M 13, ICGS 76, and TPG 41 gave pod yield more than 2500 kg/ha. The three year of data indicated that the cultivars TKG 19A, GG 20, ICGS 76, ICGV 88448, JL 24, JL 220, CSMG 84-1, ICGV 86590 and M 13 were high yielding. Among the nutrient efficient genotypes, NRCG 1308, 7206, 7471, FeESG 10-1 and FeESG 10-3 were promising which gave more than 1500 kg ha^{-1} pod yield and more than 1000 kg ha^{-1} seed yield.

The high yielding groundnut genotypes were also tolerant of Al-toxicity, resistant to ELS, LLS and rust diseases, and hence were identified as suitable for Mizoram and adjoining areas of NEH region.

Identification of groundnut varieties suitable for various intercropping systems

Field experiment was carried out in a split plot design with three intercropping systems (rice + groundnut; maize + groundnut; and green gram + groundnut) in main plots and four varieties (ICGS 76, TKG 19A, JL 24 and ICGV 86590) in subplots in the foot hills of Manipur. The soil of the experimental site was low in available nitrogen, low to medium in available phosphorus and high in available potassium. The intercropping system was fertilized with recommended doses of the respective main crop *i.e.* Rice, Maize and Green gram. The groundnut equivalent yield (GEY) was calculated using the prices of rice at Rs. 6/kg, maize Rs. 10/kg, green gram Rs. 25/kg and groundnut Rs. 15/kg only.

Table 1. Evaluation of groundnut genotypes at Kolasib (Mizoram)

Variety	Plant height (cm)	Pod yield (no./plant)	Pod yield (kg/ha)
SG 84	49.7	30	2467
M 13	53.3	27	2683
TG 26	34.7	27	2267
TAG 24	48.3	18	1867
ICGV 86590	64.0	19	2300
ICGS 76	51.0	24	2667
TKG 19 A	62.3	21	1917
CSMG 84-1	47.3	22	2200
GG 20	49.3	17	1900
Girnar 1	58.7	24	1767
FeESG 8	53.3	18	1767
FeESG 10-1	51.7	15	1733
FeESG 10-3	52.0	26	2400
NRCG 162	52.3	15	1650
NRCG 1308	64.0	19	2217
NRCG 2588	60.7	25	2167
NRCG 3498	52.7	19	2200
NRCG 5513	46.3	26	2433
NRCG 6131	39.0	23	2458
NRCG 6450	44.0	17	2083
PKVG 8	43.7	14	1725
NRCG 6820	43.0	22	1883
NRCG 7205	51.3	22	2183
NRCG 7599	62.3	26	2450
JL 24	53.7	29	2433
BG 3	51.7	12	1475
NRCG 7472	56.3	22	1933
Gangapuri	51.3	15	1217
ICGV 88448	55.3	18	2033
TPG 41	49.3	23	2667
GG 7	30.0	19	2033
TG 42	30.0	22	2000
GAUG 10	30.0	19	2033
Jyoti	46.3	26	1717
ALR 2	63.3	22	1792
TMV 2	67.7	25	1983
JL 220	60.0	21	1850
PBS 13	52.3	24	1613
GG 20	40.3	19	1967
NRCG 6155	48.7	17	1650

Among the intercropping systems evaluated, the highest groundnut yield was obtained in maize + groundnut intercropping (1766 kg/ha) which was significantly higher over other two intercropping systems (Table 2 and 3). The groundnut equivalent yields of rice + groundnut and green gram + groundnut intercropping systems were on par with each other. Among the varieties ICGV 86590 recorded the highest GEY of 1539 kg/ha followed by TKG 19A. But the highest pod yield of groundnut as a component crop was recorded in rice + groundnut intercropping system by the variety ICGV 86590.

Table 2. Performance of groundnut varieties under different intercropping systems in the foothills of Manipur

Treatment	Groundnut yield (q pod /ha)	GEY of intercrop (q pod/ha)	GEY of the system (q/ha)
System			
Rice + Groundnut	10.47	1.75	12.23
Maize + Groundnut	9.50	8.15	17.66
Green gram + Groundnut	8.36	4.73	13.09
CD (5%)	1.12	-	1.43
Variety			
ICGS 76	9.09	4.88	13.97
TKG 19A	9.57	5.15	14.72
JL 24	9.01	4.20	13.21
ICGV 86590	10.12	5.27	15.39
CD (5%)	0.87	-	1.27

Table 3. Interaction of intercropping systems and varieties for total groundnut equivalent yield (GEY) in Manipur

Intercropping system	Variety				
	ICGS 76	TKG 19A	JL 24	ICGV 86590	Mean
Rice + groundnut	11.65	11.89	9.24	16.12	12.23
Maize + groundnut	14.93	19.50	18.62	17.59	17.66
Green gram + groundnut	15.34	12.77	11.78	12.16	13.09
Mean	13.97	14.72	13.21	15.39	
CD (5%)	Intercropping system X variety = 2.15				

Table 4. Performance of groundnut varieties in intercropping system

Intercropping system	Variety				
	ICGS 76	TKG 19A	JL 24	ICGV 86590	Mean
Rice + groundnut	9.06	10.37	8.02	14.45	10.47
Maize + groundnut	7.60	10.37	10.70	8.99	9.50
Green gram +,groundnut	10.62	7.59	8.31	6.92	8.36
Mean	9.09	9.57	9.01	10.12	
CD (5%)	Intercropping system X variety = 1.54				

The interaction effect of varieties and intercropping systems was statistically significant (Table 3 and 4). It was observed that ICGV 86590 and ICGS 76 produced significantly higher GEY over the other varieties in rice + groundnut and green gram + groundnut intercropping systems but TKG 19 A, produced highest GEY in maize + groundnut intercropping system though it was at par with JL 24 and ICGV 86590. Similar result was also observed in case of pod yield of the varieties under different intercropping system.

Evaluation of confectionery groundnut genotypes in NEH region

Eight comparatively large seeded genotypes, ICGV 86590, GG 20, ICGS 76, GG 7, TKG 19 A, CSMG 84-1, TPG 41, and M 13 were evaluated for their yield potential in NEH region under high management conditions (manures FYM 10 t/ha + PSM + PGPR and all fertilizers). The six genotypes which gave yield more than 2000 kg/ha were M 13, TPG 41, ICGV 86590, ICGS 76 and CSMG 84-1 and any one of that could be used (Table 5).

Table 5. Evaluation of confectionery groundnut at Kolasib (Mizoram)

Variety	Plant height (cm)	Pod yield (no./plant)	Pod yield (kg/ha)
ICGV 86590	72.3	192	117
GG 20	65.3	21	1942
ICGS 76	59.3	24	2542
GG 7	51.3	20	1775
TKG 19 A	67.7	20	2233
CSMG 84-1	52.0	19	2300
TPG 41	47.7	22	2037
M 13	58.0	27	2520

A field experiment was conducted at Langol farm at Manipur with five confectionary groundnut varieties in RBD with four replications. Among the varieties evaluated, the largest number of pods per plant and the highest pod yield (2304 kg/ha) was recorded in the variety ICGS 76 which was followed by CSMG 84-1 (1829 kg/ha). The highest haulm yield (3511 kg/ha) and lowest harvest index was obtained in the variety GG 20. The variety ICGS 76 produced significantly higher pod yield over other varieties and the increase in the pod yield over CSMG 84-1 was 26%. The highest hundred seed mass was recorded by the variety GG 20 (49.2 g) which was followed by TKG 19A (48.6 g).

Table 6. Performance of confectionery groundnut varieties in the foothills of Manipur

Variety	Hundred seed-mass (g)	Pod yield (no./plant)	Pod yield (kg/ha)	Haulm yield (kg/ha)	HI (%)
ICGS 76	47.4	16.73	2304	3022	43.3
GG 20	49.2	14.97	1539	3511	26.0
CSMG 84 - 1	43.9	15.80	1829	3333	35.4
GG 7	46.2	14.13	1547	2667	31.7
TKG 19A	48.6	15.53	1611	2622	33.0
CD (5%)	-	-	211	312	2.97

Experiment on organic farming

Various organic farming approaches were evaluated in NEH region where organic fertilizers always showed its superiority over inorganic one. The FYM (10 t/ha) alone was the best for highly eroded soils of NEH region and helped in alleviating Al-toxicity (Tables 7 and 8). A field experiment was carried out in the Langol farm of Manipur with eight nutrient management treatments in RBD with three replications in a low available-nitrogen soil, low to medium in available phosphorus and high in available potassium using ICGS 76 (Table 7).

Table 7. Effect of nutrient management treatments on yield and harvest index of groundnut

Treatment	Pod yield (kg/ha)	Haulm yield (kg/ha)	HI (%)
T_1: Control	1093	2001	35.5
T_2: NPK (30:50:40) + lime 2500 kg/ha	2882	3689	43.9
T_3: Mixed slurry manure (cow, pig and poultry)	1762	3333	34.6
T_4: Mulching @ 20 t/ha (grass and leaves)	1218	2222	35.4
T_5: FYM @10t/ha	1656	3111	34.7
T_6: Oilcake @1t/ha (mustard)	2071	3822	35.1
T_7: Vermicompost @ 2t/ha	2142	3778	36.2
T_8: Biofertilizers (*Rhizobium* + PSB)	1780	3556	33.4
CD (5%)	173	375	3.9

Table 8. Response of groundnut cv. ICGS 76 to organic manures at Kolasib

Treatment	Plant height (cm)	Pod (no./plant)	Pod (kg/ha)
Control	43.3	15	1073
N30P50 + Lime (2.5 t/ha)	54.1	29	2467
FYM (10 t/ha)	54.4	26	2317
Neem seed cake (500 kg/ha)	51.2	23	1867
Pig manure 10 t/ha	55.9	29	2133
Biofertilizer	49.3	20	1267
Vermicompost (2t/ha)	55.5	26	2267
Poultry litter 10 t/ha	60.9	27	2267

In all the nutrient management treatments, a significant increase in pod yield was obtained over the control, except mulching @ 20 t/ha. The highest pod yield was obtained with application of recommended doses of NPK (30:50:40) and this yield was significantly higher than those of other treatments. Among the organic treatments vermicompost @ 2t/ha produced the highest pod yield (21.42 q/ha) which was at par with that obtained with the application of oil cake @1t/ha but was significantly higher than that obtained with other organic treatments. Highest haulm yield was obtained with application of oilcake @1t/ha (938.22 q/ha) followed by vermicompost @ 2t/ha, however, these values were statistically at par with that of biofertilizer treatment and recommended doses of NPK. The highest harvest index was recorded with application of recommended dose of NPK and the value was significantly higher than the values of all the other treatments.

In Mizoram, the biofertilizers comprising 'PSM + PGPR' increased the kernel yield, by 25% whereas the VAM alone increased the kernel yield by 58%. The Neem cake (500 kg/ha), pig slurry (10 t/ha), vermi-compost (5 t/ha) and poultry manure increased the kernel yield by 75, 85, 127 and 116%, respectively compared to increase by 133 % due to application of FYM.

In Tripura, the promising organic sources, in descending order, were cowdung compost (10 t/ha), mustard oil cake (1 t/ha), and *Gliricidia* green leaf (10 t/ha). The green leaves of *Gliricidia* and subabul, however, showed the residual effect.

Nutrient management in large-seeded groundnut

The NEH region has a good potential for growing confectionary groundnut as water is not a limiting factor and genetic potential is expressed to much greater an extent than it is expressed elsewhere. In highly leached acid soils, however, there is improper kernel formation. Hence, experiments were conducted to study the nutrient management in large-seeded groundnut genotypes by applying various combinations of nutrients. Application of P and lime is essential and an increase in seed yield by 52% and 46% was obtained by application of P50 and lime @ 2.5 t/ha and , respectively (Table 9). The affect of supplementing B was also noticed. In Mizoram, application of P50 + K100 + Lime 2.5 t/ha + FYM (10 t/ha) gave a pod yield of 2017 as against 733 kg/ha in control. The next highest yield of 1667 kg/ha was obtained with application of P50 + K100 + Borax and 1650 in P50 + K100 + lime. It was thus concluded that the large-seeded groundnut need to be fertilized with micronutrients as well.

Table 9. Effect of nutrition on large-seeded groundnut variety GG 7 at Kolasib

Treatment	Plant height (cm)	Pod	
		(no./plant)	(kg/ha)
Control	32	12	733
P50 (50 kg P_2O_5/ha)	39	18	1117
K100 (100 kg K_2O /ha)	39	17	1083
Lime (2.5 t/ha)	39	17	1067
P 50 + lime (2.5 t/ha)	47	22	1367
P 50 K100 + lime (2.5 t/ha)	47	26	1650
P 50 K100 + borax (1kg B/ha)	47	27	1667
P 50 K100 + lime (2.5 t/ha) + FYM (10 t/ha)	50	30	2017

Basic studies on Al-toxicity at NRCG

Screening of groundnut genotypes

Thirty-five groundnut genotypes were screened for their tolerance of Al-toxicity (1000 μM of Al as $AlCl_3$). The Al-toxicity symptoms on roots and subsequently on growth of plants were noticed at 25-30 days after sowing, causing reduction in growth and yields. The genotypes ICG 11882, GG 3 and 1038, NRCG 3498 and FeESG 8, however, showed comparatively more tolerance than other genotypes.

PROJECT 08: GERMPLASM MANAGEMENT OF CULTIVATED GROUNDNUT (*Arachis hypogaea* L.) AND ITS WILD RELATIVES

(K. RAJGOPAL, S. K. BERA, V. NANDAGOPAL, VINOD KUMAR AND V. V. SUMANTH KUMAR)

Acquisition of germplasm

The working collection was enriched by assembling 31 accessions from various sources. These accessions included nine wild *Arachis* species, thirteen local, and nine registration material and land races collected from NBPGR, Ranchi station. Two variants of GG 20 having high oil (>50%) content were also collected through local exploration.

Distribution of germplasm

Twenty-four indenters were supplied a total of 1362 accessions to support the ongoing crop improvement programmes NRCG (346 accessions), ICAR institutes (11 accessions) and various universities (955 accessions). These lines comprised released cultivars, high yielding and promising accessions and also the wild *Arachis* species.

Multiplication of germplasm for conservation

One set of gemplasm collection was deposited with the National Gene Bank (NGB) at NBPGR, New Delhi for long-term conservation. NRCG being one of the National Active Germplasm Sites (NAGS), multiplication of a working collection of 713 accessions was undertaken in the rainy season. This collection included the repatriation material and exotic accessions. Sufficient quantity of seed was regenerated for 322 accessions and then deposited in NGB.

Characterization of germplasm

Mini core collection

Seeds of 184 accessions (VUL: 64, FST: 38, HYB: 42, & HYR: 40) received from ICRISAT under mini core trial programme were sown along with respective check varieties *viz.*, GG 2, JL 24, Gangapuri, MH 2, GAUG 10, M 13, GG 20 and Kadiri 3. These accessions were characterized for 19 qualitative and 27 quantitative traits. Observations were taken randomly on length and width of leaflet, length of main axis, number of primary and secondary branches; and pods on randomly selected five plants. The number of pods was further grouped into immature and mature lots.

The same set was also simultaneously evaluated at Jalgaon centre of AICRP (G). For most of the quantitative and the qualitative traits a wide variability was observed (Table 1). High variation as indicated by high coefficient of variability (CV %) for pod yield (g/plant and g/m^2), pod length and 100-seed mass at both the locations was observed whereas at Jalgaon the variations observed for seed length and seed width was much greater than those observed at Junagadh.

Released cultivars

Seeds of 120 released varieties (VUL: 60, FST: 04, HYB: 32, & HYR: 24) of all the four habit groups were sown in Randomized Block Design (RBD) with three replications with a spacing of 60x10 cm in single rows and of 5m length in *kharif* season. The varieties were characterized for 19 qualitative and 27 quantitative traits. Observations on four randomly selected plants were recorded for length and width of leaflet, length of main axis and primary branch, number of primary and secondary branches, number of immature and mature pods. The varieties also conformed to their traits as per DUS test guidelines and some of the traits, which help in identification of varieties, are given in Table 2.

Table 1. Variation in agronomic traits of ICRISAT core germplasm collection grown at two locations

Trait	Junagadh				Jalgaon			
	Min	Max	Mean	CV (%)	Min	Max	Mean	CV (%)
Days to 50% flowering	21.0	29.0	22.9	6.1	27.0	38.0	30.1	5.1
Days to maturity	106	139	121	8.9	112	131	117	3.2
Pod yield (g/plant)	1.0	21.8	7.5	57.0	2.8	13.0	6.0	34.7
Pod yield (g/m^2)	32	185	83	40.0	47	217	100	34.7
Pod length (mm)	17.0	44.5	26.8	17.7	17.0	47.0	28.5	19.3
Pod width (mm)	8.0	17.0	11.9	11.6	7.0	19.0	12.1	14.4
Seed length (mm)	8.0	19.0	12.7	16.7	7.0	20.0	13.8	20.6
Seed width (mm)	5.0	8.5	6.9	9.7	5.0	11.0	6.6	15.8
Shelling out turn (%)	52.1	82.4	63.3	8.7	55.3	72.0	64.5	4.9
Sound mature kernels (%)	50.0	98.4	87.8	9.1	76.0	95.0	87.6	3.7
Hundred seed mass (g)	15.0	58.4	32.8	26.7	16.8	60.0	29.9	19.6

Table 2. Distinguishing features of some released varieties

Variety	Distinguishing features
Chitra and CSMG 84-1	Variegated seed coat colour (salmon + white)
Kaushal (G 201)	Flower on main steam, thick shell
Tirupati 3	Red testa colour
ALR 1	Dark red testa colour
BAU 13	Bold pods, red testa colour, thick shell
BAU 19	Red testa colour, thin shell
DRG 12	Small pods
M 145	Red testa colour
RS 138	Red testa colour
RSB 87	Red testa colour
TMV 10	Variegated testa colour
OG 52-1	Red testa colour
Gangapuri	Red testa colour, two to three seeded, smooth pods
ICGV 86590	Two to three seeded, reticulated shell
MH 2 and MH 4	Dwarf plant type
DH 3-30	Very small pods with light reticulation, thick shell
Girnar 1	Two to three seeded pods with medium beak
ICG (FDRS) 4	Elongated rachis, high reticulation, thick shell
JL 24	Smooth pods, greener large leaflets
TG 26	Dwarf plant, two to three seeded, smooth pods
TKG 19 A	Medium bold pods, thick shell, dark green leaves
ALR 2	Dark green waxy type leaves, late maturity
Somnath	Flower on main axis, compact plant
GG 2	Thicker and green leaves

Significant differences were seen in all the qualitative traits (Table 3). The coefficients of variations were high for number of mature pods, one- and three-seeded pods and mass of pods/plant.

Table 3. Variation in agronomic traits among the released varieties

Trait	Min	Max	Mean	MS	CD (5%)	CV (%)
Days to first flowering	17.67	26.67	21.17	11.66	1.48	5.21
Length of leaflet (mm)	4.27	6.47	5.24	0.60	0.56	7.92
Leaflet width (mm)	1.87	2.77	2.25	0.14	0.29	9.45
Leaf length:width ratio	2.03	2.77	2.33	0.06	0.21	6.65
Mature pods (no./plant)	3.43	17.13	9.48	18.19	3.80	29.92
Days to maturity	106.67	127.67	115.75	170.74	2.77	1.79
Single-seeded pods (no./plant)	4.83	41.93	14.26	135.78	8.22	43.03
Two-seeded pod (no./plant)	33.73	94.27	81.17	425.60	9.45	8.69
Three-seeded pod (no./plant)	0.00	59.37	4.55	351.98	7.96	130.52
Pod length (mm)	18.67	34.83	25.09	37.43	2.57	7.64
Pod width (mm)	9.33	16.83	11.55	4.03	0.92	5.94
Seed length (mm)	9.50	17.17	12.45	8.14	1.28	7.68
Seed width (mm)	5.67	8.50	6.88	0.89	0.80	8.65
Hundred pod mass (g)	50.93	130.40	80.68	821.01	14.46	13.38
Shelling outturn (%)	55.27	72.10	64.07	52.00	5.87	6.85
Sound mature kernels (%)	74.27	96.77	90.11	48.79	5.25	4.35
Hundred seed mass (g)	22.13	57.87	34.74	158.81	7.76	16.67
Pod yield (g/m^2)	33.33	219.47	105.58	4522.12	34.73	24.56
Pod yield (g/plant)	3.33	50.60	11.33	70.58	9.74	64.18
Dry biomass (g/plant)	7.17	46.08	21.33	177.90	8.62	30.17

Variability museum

About 45 germplasm lines having the variability for leaf colour, leaflet shape and size, standard petal colour, stem and peg pigmentation and also the pod size, constriction, beak and reticulation, etc. were maintained in the NRCG museum.

High oil lines

Twenty-two lines identified earlier as high oil lines earlier, were grown in *kharif* season for further confirmation. The oil content was in the range of 48.0-53.0% in 22 lines. The NRCG nos.' 11918, 6677, 4781, 13126, 13167 and GG 20 had>52.0% seed oil content.

Evaluation of large-seeded accessions

Thirty-two accessions representing 17 Virginia bunch, 10 Virginia runner, 4 Spanish and 1 Valencia types were evaluated for the second year to identify promising ones. The highest pod yield was recorded in NRCG nos.' 988, 10081, 10089, and 12133, which ranged from 123-144.10 g/m^2. Similarly, the 100-seed mass was in the range of 51.07-55.93 g in NRCG nos.' 5405 (SB), 9036 (HYB), 12074 (HYB), 12157 (HYB) (Table 4).

Table 4. Range of variability in large seeded collection

Traits	Min	Max	Mean	MS	CD(5%)	CV(%)
Days to maturity	118.00	132.00	127.06	65.63	3.30	1.15
Shelling out turn (%)	51.07	71.57	63.48	55.00	4.44	5.17
Sound mature kernels (%)	64.47	90.93	81.78	61.64	NS	6.97
Pod yield (g/m^2)	34.10	144.10	85.20	2309.87	29.78	25.83
Pod yield (g/plant)	1.90	13.13	7.74	19.06	3.05	29.16
Hundred seed mass (g)	24.00	55.93	39.04	168.32	6.91	13.08

Maintenance of wild *Arachis* species

Ninety-six accessions representing five sections: *Procumbentes* (06), *Erectoides* (04), *Arachis* (49), *Heteranthae* (02) and *Rhizomatosae* (35), were maintained. Out of 60 wild *Arachis* accessions received from the ICRISAT, 15 new accessions were sown but only seven survived. Including this new collection, the status of field maintenance of the wild *Arachis* species was as under:

Section	No. of accessions	No. of species
Arachis	49	18
Erectoides	04	03
Heteranthae	02	02
Procumbentes	06	03
Rhizomatosae	35	01
Total	**96**	**27**

Documentation

The data generated on the germplasm accessions grown in *kharif* season was documented using the Foxbas programme. For the accessions conserved in medium term storage (5-7 years) a data base was also prepared f easy retrieval of information.

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

(RADHAKRISHNAN T., LUKE RATHNAKUMAR, CHUNI LAL, S. K. BERA VINOD KUMAR, K. HARIPRASANNA AND T. V. PRASAD)

Interspecific hybridisation

Isolation of hybrids

Probable putative hybrid pods of six interspecific (or probable pods of six interspecific croses) and three inter-varietal crosses were sown during rainy season for isolation of true hybrids. True hybrids were isolated in all cross combinations except J11 x *A. rigonii* (Table 1). The hybrids of five interspecific crosses were characterized and treated for colchiploidy. Pods were harvested from fertile F_1 hybrids for further use. Similarly, half of the hybrid pods of inter-varietal crosses (Table 1) were sown to develop F_2 generation. Parent, F_1 and F_2 generations of these inter-varietal crosses would be screened simultaneously for resistance to stem rot pathogen in next rainy season.

Table 1. Cross wise number of pollinations made and hybrids isolated

Parents	Pollination attempted (number)	Probable cross pods harvested (number)	Hybrids isolated (number)
J11 x *A. diogoi* (NRCG 11781)	574	300	06
J11 x *A. batizocoi* (NRCG 12030)	539	353	10 (normal) 13 (abnormal)
J11 x *A. monticola* (NRCG 11800)	603	430	08
J11 x *A. pusilla* (ICG 8131)	592	360	41
J11 x *A. kretschmeri* (NRCG 12029)	608	340	28
J11 x *A. rigonii* (NRCG 12032)	601	450	Nil
OG 52-1 x NRCG CS 19	257	155	
ICGV 86590 x NRCG CS 19	473	250	
Puckered x crinkle	612	200	27 crinkle

Advancement of segregating lines

Sixty-eight segregating lines of five crosses developed studying inheritance were sown for advancement of generation in summer season. The segregating ratio of F_1 and F_2 generations revealed that 'crinkle-leaf' and 'white-testa' versus 'crinkle-leaf' and 'red-testa' segregated independently and were monogenic in nature. A total of seventy lines were advanced to F_4 generation on the basis of their agronomic performance in the field (Table 2).

Table 2. Cross-wise number of lines advanced to next generation

Parents	Selections sown	Selections made
Purple-tan x dark-red	15	15
White-flower x crinkle-leaf	20	20
White-testa x crinkle-leaf	17	17
Red-testa x crinkle-leaf	13	15
ICGL 5 x crinkle-leaf	03	03
Total	68	70

Induction of variability through chemical mutagenesis

Kernels of cv. GG 2 were treated with three chemical mutagens i.e. EMS, colchicine and chloramphenicol. For fixation of desirable mutants, 110 selected M3 lines were advanced to the next generation. The variability estimates of selected population showed promise for haulm yield, pod yield, biological yield, kernel yield, harvest index and shelling turnover compared to check cv. GG 2 (Table 3). This indicates that the traits studied may be improved through repeated selection.

Table 3. Variability estimates of M4 generation developed by chemical mutagenesis

Statistical attributes	Haulm yield (g/plant)	Pod yield (g/plant)	Kernel yield (g/plant)	Biological yield (g/plant)	HI (%)	Shelling turnover (%)
Range	13.6-92.0	7.6-36.0	5.0-25.48	25.2-118.7	6.6-38.2	46.0-81.1
Mean	41.8	21.0	13.6	62.8	22.3	64.8
SE	1.4	0.5	0.4	1.7	0.6	0.7
CV (%)	35.54	27.33	29.69	28.79	26.78	10.91
GG 2 (check)	18.0	18.0	12.8	36.0	35.6	71.1

All the three mutagens showed a similar trend in their mutagenic action. The maximum variation was induced in biological yield and haulm yield, while no significant variation was observed in pod and kernel yields (Figure1).

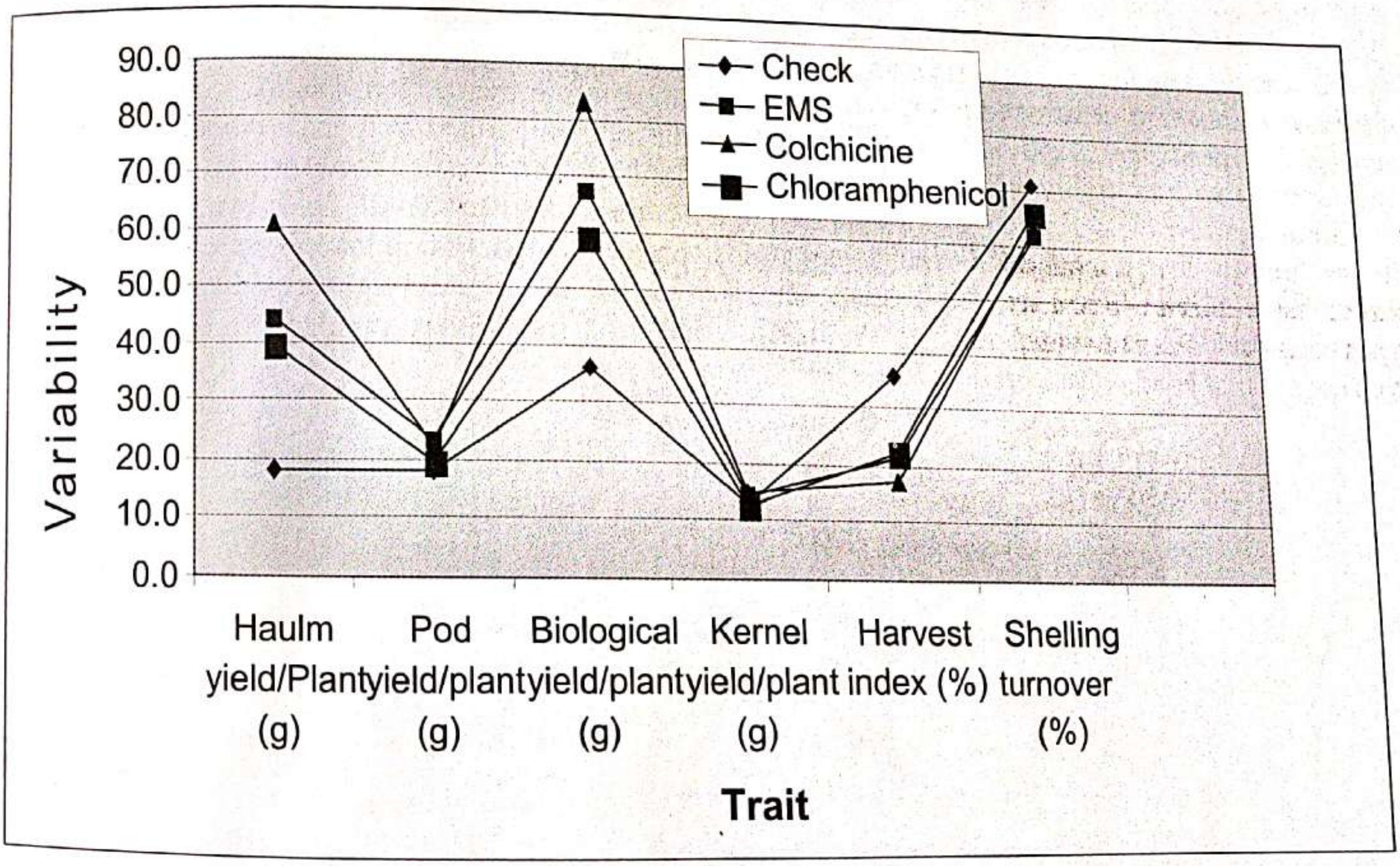

Figure 1. Comparative effect of three mutagens on plant characters

Evaluation of advanced lines

During summer season, 120 advanced breeding lines were evaluated in augmented design in field conditions. After harvest, the genotypes were assessed for pod yield, shelling out turn, sound mature kernels, and hundred kernel mass. Compared to best check, sixteen genotypes (CS nos. 237, 240, 241, 242, 251, 259, 268, 281, 287, 289, 291, 296, 297, 312, 322, and 347) were superior in pod yield (g/plant), thirteen (CS Nos. 240, 248, 270, 287, 302, 306, 315, 332, 336, 342, 345, 346, and 350) in shelling turnover (%), fifty-one (CS nos. 241, 243, 244, 253, 256, 258, 260, 265, 266, 268, 269, 272, 276, 278, 281, 287, 289, 291, 292, 295, 297, 299, CS300, 301, 302, 303, 304, 305, 306, 336, 344, 355, 307, 311, 312, 322, 325, 327, 332, 342, 345, 309, 313, 314, 316, 330, 331, 347, 350, and 3510) in SMK (%) and seven (CS Nos. 255, 268, 269, 281, 283, 285, and 313) in HMK (g). The experiment will be repeated in the next season for confirmation.

Screening of advanced lines for tolerance of salinity

For salinity tolerance, 150 advanced breeding lines were screened in pots. Germination of seeds was recorded in three different salinity regimes i.e. 4 EC, 8 EC and 12 EC with three replications. More than 50% germination was recorded in 22 genotypes in 4EC salinity and in four genotypes under 8 EC salinity, respectively. None of the genotypes showed acceptable level of germination (>50%) under 12 EC salinity, alhough 12 genotypes showed 6 to 13% germination.

Marker studies

SSR analysis of the wild species, interspecific hybrids, and progenies using additional SSR primers

The composite data on the allelic frequencies when clustered using the Squired Euclidian Distances and the dendrogram revealed 23 clusters indicating the wide variability in the collection of the *Arachis* species analysed (Figure 2). All the habit types of the cultivated species, *Arachis hypogaea* grouped together. The other six species of the section *Arachis viz., A. cruziana, A. helodes, A. kempff-mercadoi, A. magna, A. correntina* and *A. duranensis* clustered nearby while the other species belonging to the section *Arachis* viz. *A. cardenasii, A. benensis, A. stenosperma* and *A. cryptopotamica* were distinctly separated from each other and clustered with other species without following any definite pattern. The members of other sections also did not follow any definite pattern of clustering so that a distinct phylogenetic conclusion could be drawn. The most striking observation was that *A. monticola*, which is supposed to be very near to the cultivated species fell far away in the cluster. The maximum distance between the species was 25 and the minimum distance between the *A. hypogaea* types was nearly one. It was inferred from the cluster analysis that for deriving phylogenetic conclusions, use of a even larger number of markers may be required.

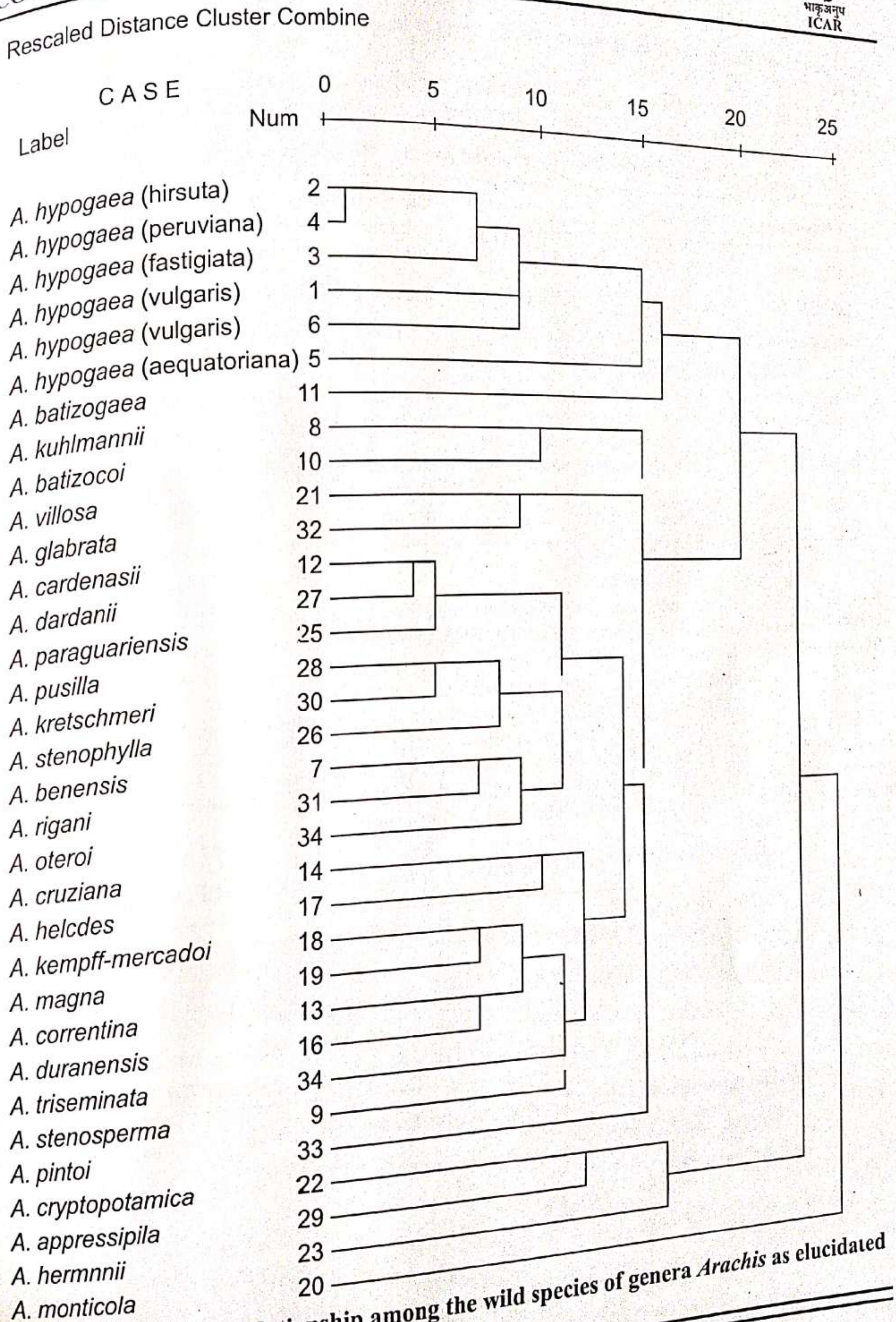

Figure 2. Phylogenetic relationship among the wild species of genera *Arachis* as elucidated by SSR markers

Analysis of selected genotypes, their crosses, and progenies for identification of marker (early and late leaf spots, rust and stem rot)

The genotypes GG 20, CS 19, ICGV 86590, PBS 24030 and GPBD4 along with progenies of their crosses with CS 19 were analyzed using 36 SSR primers and the gels were scored for the markers (Figure 3).

Table 4. The genotypes and their crosses used for the SSR analysis

Genotype	Pedigree	Characteristics
GG 20	GAUG 10 X R 33-1	Susceptible to stem rot
GPBD 4	KRG 1 X ICGV 86856	Resistant to foliar diseases (LLS and rust)
ICGV 86590	X14-4-B-19-B X PJ259747	Resistant to foliar diseases (LLS and ELS, rust) and to PBND and *Spodoptera litura*
PBS 24030	M 13 X R 33-1	Resistant to foliar diseases (LLS and rust), PBND, and tolerant of thrips
CS 19	TMV 2 X *A. chacoense*	Resistant to stem rot, collar rot, *Alternaria* blight and tolerant of LLS, ELS, rust, and PBND

With the 36 primers used, the number of alleles varied from 1 to 18 and that of polymorphic alleles from 1 to 13. The extent of polymorphism varied from 20 to 100% and six primers were found to be highly polymorphic. The primer PM 50 elicited 100% polymorphism with a specific primer index (SPI) value of 6.7616. The primer PM 36 and PM 42 also showed high SPI values and high degree of polymorphism. These three primers can be effectively used for screening of polymorphism in the cultivated varieties of groundnut for identification trait based markers. Most of the primers used amplified alleles mostly of low molecular weight. Certain low molecular weight alleles were specific for the parental lines e.g., 64 bp allele amplified by PM 65 in ICGV 86590; 39 bp allele amplified by pPGPseq2G3 in GPBD 4; and 44 bp allele amplified by PM 03 in CS 19. However, this specificity of the low molecular weight alleles requires confirmation.

Table 5. Size (number of base pairs) of alleles amplified in the F_1 hybrids

No.	Hybrid	Size of allele (bp)
1	CS 19 x GG 20	117
2	CS 19 x GPBD 4	42 , 268 , and 310
3	CS 19 x ICGV 86590	38, 43, 44, 48, 87, 90, 205, and 224
4	CS 19 x PBS 24030	47, 163, 184, 201, 207, and 228

The identified genotypes will be used to study the inheritance of the polymorphic markers to associate with the characters of relevance.

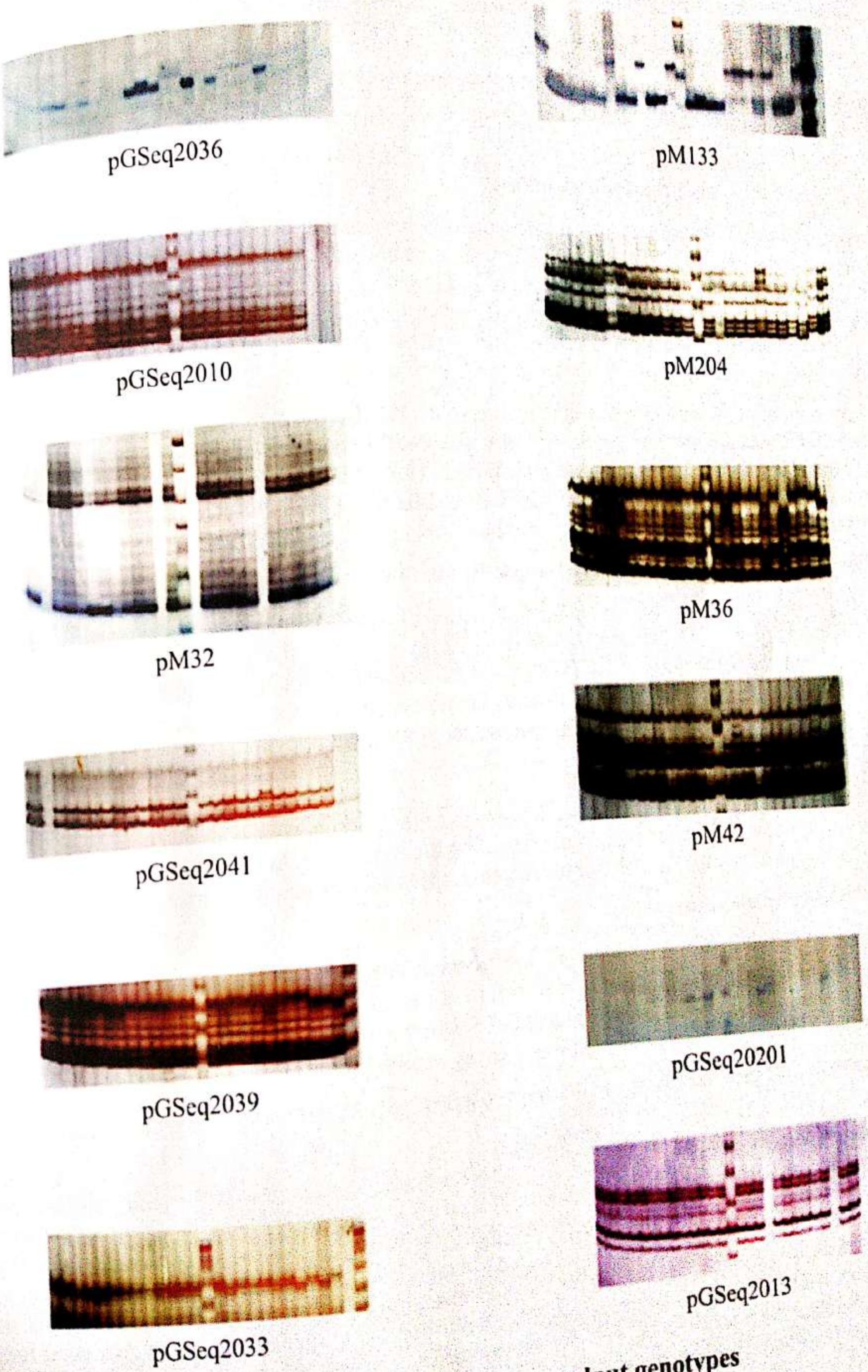

Figure 3. SSR profiles of groundnut genotypes

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

(J. B. MISRA, K. K. PAL AND R. DEY)

Sub-project 1: Assessment of quality in germplasm collection, breeding material and produce of other experiments

(J. B. Misra)

Protein and oil contents of groundnut cultivars

Kernel samples of 71 cultivars grown in *kharif* 2006 were analyzed for protein content. The protein content ranged from 16.7% (M 335) to 30.7% (SG 84) with a mean value of 22.8%. Sixteen cultivars having protein content higher than 25.0% were identified *viz.*, JL 24 (25.8%), GG 3 (28.4%), GG 13 (27.5%), GG 20 (25.5%), ICG (FDRS) 4 (25.3%), S 230 (26.0%), S 206 (25.6%), Kadiri 3 (26.1%), Tirupati 2 (27.8%), ICGV 86325 (25.9%), B 95 (26.3%), TKG 19 A (28.2%), ALR 1 (27.4%), VRI 3 (25.7%), BAU 19 (26.0%), and M 13 (25.4%).

The oil content of 54 cultivars was in the range of 41.3% (DRG 12) to 51.9% (ICGV 86031) with a mean value of 47.7%. The genotypes having oil content higher than 50.0% were Jawan, GG 5, ICG (FDRS) 10, Kisan, TG 64, S 206, ICGV 86590, ICGS 1, M 335, BG 3, BAU 19, CSMG 84, ICGV 86325 and M 13. Kernels of nine cultivars TMV 2, RG 141, Karad 4-11, ICGS 76, DRG 12, M 145, UF 70-103, Tirupati 3, and Tirupati 2 had less than 45.0% oil content.

Evaluation of core germplasm collection for quality attributes

The kernel samples of the core germplasm collection of NRCG comprising 126 accessions were analyzed for oil and protein contents. The oil content was in the range of 40.6 to 50.8% with a mean value of 45.4% while the protein content was in the range of 18.2 to 29.8% with a mean of 25.1%. The frequency distribution curves for oil and protein contents indicated a normal distribution about the mean for both the parameters. The correlation coefficient between the values of the oil and protein contents was negative (0.209).

Vitamin C content of groundnut kernels

Preliminary investigations indicated that the kernels of freshly harvested pods do contain small amounts (1-3 mg/100g) of vitamin C. Further studies revealed that the developing kernels (in pod filling stage), contain appreciable amounts of vitamin C, which gradually decreases with increasing maturity of pods.

Allergen content of groundnut varieties

Using ELISA kits, the allergen content of 19 cultivars was determined. The cultivars differed in their kernel allergen contents. The allergen of these cultivars was in the range of 0.931-1.586 in terms of OD_{450}. Kernel samples of cultivars GAUG 10, JL 24, Jawan and GG 5 were found to contain low allergen levels while those of cultivars GG 20, TG 26, GG 7, B 95 and M 13 were having relatively high levels.

Determination of nutritive value and organoleptic qualities of *chapatis* prepared from wheat fortified with groundnut

Chapatis prepared from wheat-groundnut composite flours were evaluated for their nutritive value and organoleptic property. The composite flours were prepared by grinding a mixture of wheat grains and groundnut kernels in five different proportions (w/w) *viz.*, 100:0, 95:5, 90:10, 85:15, and 80:20. The proximate composition of composite flours thus prepared was worked out by calculation on the basis of standard nutrient compositions of these foodstuffs. The energy, protein, fat, mineral and fibre contents of the composite flours increased with the increasing proportions of groundnut while the carbohydrate content decreased. Mixing of groundnut, improved the protein content of the flours as well as EAAI of protein. The *chapatis* prepared from a flour of 80:20 mixture of wheat and groundnut was adjudged to be the best from the organoleptic point of view (Table 1)

Table 1. Organoleptic and nutritive value of *chapatis* prepared from wheat fortified with groundnut

Ratio	Composition per 100g product							
	Energy (K cal)	Carbohydrate (g)	Protein (g)	Fat (g)	Minerals (g)	Fibre (g)	EAAI	OR
100:0	346	71.2	11.8	1.5	1.5	1.2	0.642	5.3
95:5	357	68.9	12.5	3.4	1.5	1.3	0.648	5.5
90:10	368	66.7	13.2	5.4	1.6	1.4	0.653	5.1
85:15	379	64.4	13.8	7.3	1.6	1.5	0.659	5.9
80:20	390	62.2	14.5	9.2	1.7	1.6	0.664	6.1

W=wheat, G =groundnut, EAAI=Essential amino acid index, OR =organoleptic ratings (average of subjective evaluation by 8 panelists on 1-10 scale)

Groundnut *Chat*

A recipe for 'Groundnut *chat*' was developed. The ingredients required for preparing this dish are given in Table 2. The step-wise method of preparing this dish is described here. Take about 2 L water in pressure cooker (capacity 5L) and heat till it starts boiling. Add rock salt, turmeric powder and cleaned groundnut pods (wash the pods, if required to remove the soil particles, etc.), close the lid and pressure-cook for about one hour. Allow cooling.

Cut salad items separately in to small pieces. Take out kernels from the pods. Remove the red skins from kernels. Add all the salad items and mix. Sprinkle, *chat masala*, salt, red chilly powder, roasted cumin powder, lemon juice as per taste and serve (see photograph). The dish was found to be acceptable by the majority of the subjective evaluators.

Table 2. Ingredients required for preparing groundnut *chat*

Ingredients		Items for salh	
Groundnut pods	1kg	Onion	500 g
Rock salt	3 tsp	Tomato	500 g
Turmeric powder	2 tsp	Cucumber	250 g
Salt	to taste	Raw mango	250 g
Chat masala	4-5 tsp	Green chillies	5-6 pieces
Red chilly powder	2 tsp	Lemon Juice	8-10 tsp
Roasted cumin powder	2 tsp		

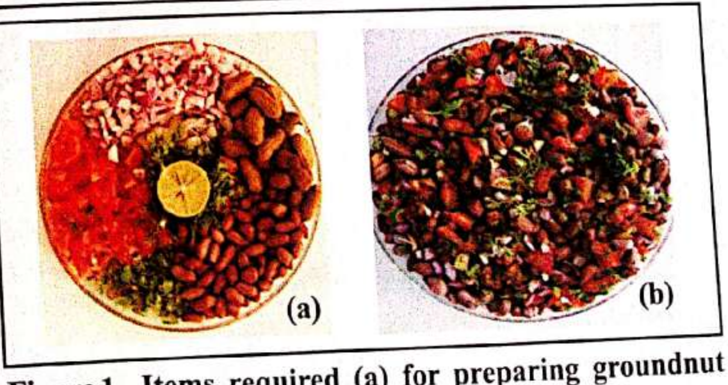

Figure 1. Items required (a) for preparing groundnut chat and the final preparation (b)

Services rendered to other sections/AICRP(G) Centres

A total of 1578 groundnut kernel samples received from Plant Breeding, Agronomy, Plant Physiology, Soil Science, Entomology, and Cytogenetics sections of NRCG and AICRP centers were analyzed for oil content and the results were furnished to the respective sections/centers. Another 187 samples received from Soil Science and Entomology sections were analyzed for protein content. Fatty acid composition of 58 kernel samples received from Soil Science section was also determined.

Sub-project 2: Biotransformation of groundnut byproducts into useful products

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

Production of industrially useful enzymes by microbial processing of groundnut byproducts

Three microorganisms, *Bacillus amyloliquefaciens* (known for production of amylases), *Bacillus* sp. (isolated at NRCG) and *Aspergillus oryzae* (both known for producing protease) were cultured on groundnut de-oiled cake. Besides the main product, the crude extracts were analyzed for the activities of other enzymes. In addition to neutral, alkaline and acid amylases (the main product) the extract of *B. amyloliquefaciens* also contained cellulase (approx. 1%) and protease (2.6%). Similarly, besides protease (63%, the main product) the extract of *Bacillus* sp. contained about 20% each of cellulase and acid amylase while the extract of *A. oryzae* besides containing protease (77%, the main product), also contained 13% cellulase and 9% amylase (alkaline + acidic).

Studies on shelf life of amylase extracted from *Bacillus amyloliquefaciens* indicated that about 50% activity was lost during two months of storage at 4°C.

Improvement of protease production potential of *Bacillus subtilis* P5 by UV mutation

Physical mutagenesis was carried by ultraviolet irradiation to improve the protease production potential of *Bacillus subtilis* P5. Out of 300 mutants isolated, purified and evaluated *in vitro,* mutant UVM168 produced a casein hydrolysis zone of 24 mm on skimmed milk-agar compared to a zone of 15 mm produced by the wild strain *Bacillus subtilis* P5. The mutant, UVM168, along with the wild type was further evaluated for its protease production potential in slurry fermentation of de-oiled groundnut cake. After 24 h of incubation, it was found that the production potential of mutant UVM168 for neutral protease was 1.5 times that of wild type.

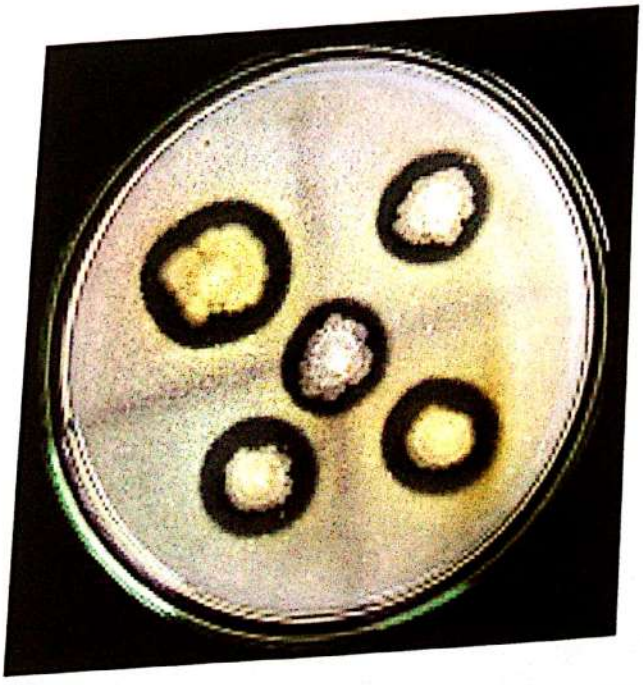

Figure 2. Zones of proteolysis by the mutant UVM168 and *Bacillus subtilis* P5

PROJECT 11: PREVENTION AND MANAGEMENT OF MYCOTOXIN CONTAMINATION IN GROUNDNUT

(VINOD KUMAR AND M. P. GHEWANDE*)

* Up to July 2006

The research work pertaining to the common objectives envisaged under this Project was carried out under the externally funded network project on mycotoxins "Prevention and management of mycotoxin contamination in commercially important agricultural commodities" an ICAR network project that was being implemented at NRCG since December 2004. The results are presented under the externally funded projects.

PROJECT 12: SOCIO-ECONOMIC STUDIES OF FARMERS DEPENDENT ON GROUNDNUT BASED LIVELIHOOD SYSTEMS

(G. D. SATISH KUMAR)

Socio-economic profile of groundnut farmers

The survey of practices followed by the farmers in and around Junagadh district of Gujarat State indicated that majority of the groundnut farmers (70%) had education only up to primary level and about 10% farmers were illiterate while the rest were functionally literate. Most of the farmers belonged to the dominant caste in the social system and were following the joint family system with more than five members in the family, living in well-built *pacca* houses. These farm families had the necessary household items like TV, telephone, refrigerator, motorcycle and more than 60% of farmers had even cell phones. Use of farm implements such as seed drill, multi-purpose tool bars, threshers, sprayers, etc. was very common among these farmers and 25% of the farmers possessed a tractor too.

Adoption of improved technologies

The average holding of the farmers was 5 *bigha* (2.8 ha). Although most of the farmers owned a bore-well, they used the same for providing supplementary irrigation at critical stages of the crop because the availability of water from the bore-wells too depends on rain fall. More than 40% of the farmers had their soil tested for nutrient status but only 15% were applying fertilizers based on soil test results. The most popular groundnut varieties among the farmers were GG 20, GAUG 10, Punjab 1 and a local variety called 'Tata Sumo'. Most of the farmers practice the seed treatment technology prior to sowing using fungicides but application of *Rhizobium* was not practiced. For semi-spreading varieties such as GG 20, the farmers were using a higher (120-150 kg/ha) seed rate than the recommended one (100 kg/ha).

Almost 50% of the farmers apply organic manures/FYM in their fields. Almost all the farmers practicing manual weeding and 60% of the farmers even applied weedicides for controlling weeds. More than 50% farmers applied gypsum at right stage and in right dose. There was a critical gap in the management of fertilizers. Most of the farmers were not using ammonium sulphate (AS), single super phosphate (SSP) and muriate of potash (MOP) application of nutrients in a balanced manner and were instead applying only di-ammonium phosphate (DAP) and that too in doses higher (200-250 kg/ha) than recommended. The farmers reported that yellowing due to Fe and Zn deficiency was increasing year after year, but they were not adopting any control measure for the same.

The important insect-pests as perceived by the farmers were sucking pests such as thrips, jassids, and aphids and also *Helicoverpa* to a less extent. Farmers were adopting chemical control measures for the insect-pests. The important diseases known to them were stem rot and collar rot, and to some extent leaf spots and rust. Only a small number of farmers (15%) were aware of aflatoxin contamination in groundnut. The farmers were generally not taking appropriate post-harvest care of their produce and stored the groundnut pods in form of heaps directly on the floor of the rooms instead of packed in polythene lined gunny bags.

The farmers desired to have a variety like GG 20 with resistance to stem rot and collar rot. The variety GG 20 is very popular among the farmers of Saurashtra region in spite of its susceptibilities to stem rot and collar rot diseases.

PROJECT 13: BREEDING FOR LARGE-SEEDED AND CONFECTIONERY TYPE GROUNDNUT

(HARIPRASANNA, K., RADHAKRISHNAN, T., CHUNI LAL, J. B. MISRA AND VINOD KUMAR)

New large-seeded and confectionery type groundnut cultures and germplasm accessions were acquired from different centers and fresh crosses effected for incorporating large seed size. The segregating generations were advanced and selections were made. An account of activities undertaken is as follows:

Hybridization

During *kharif* 2006, nine crosses were attempted to incorporate large seed size coupled with high yield. In addition, three crosses were attempted involving extremes of oil content and seed size for generating mapping populations. Advanced breeding lines from NRCG and ICRISAT, and germplasm lines were used in hybridization programme. A total of 2640 buds were pollinated and 274 probable hybrid pods were harvested (success rate: 10.4%).

Raising F_1s and identification of true hybrids

Eighteen crosses generated in a LxT design were raised in a RBD with two replications along with parents. True hybrids were identified and pods were harvested separately for further advancement. Six generations (F_1, F_2, P_1, P_2, BC_1 and BC_2) of two crosses generated for GMA were raised in a RBD with two replications. A total of 154 true hybrids were identified. Due tc excessive and prolonged rains in the season the experiment was vitiated.

Selection and generation advancement

The F_2 generations of 30 crosses were sown and true F_2s (segregating) were identified and bulk harvested for advancing. Three crosses in F_3 were sown and progenies were harvested in bulk, and 14 crosses in F_4 were advanced without selection. Phenotypic selections were carried out in F_5 and F_6 generations and 37 selections were made for advancement (Table 1). Development of new advanced breeding lines out of 31 selections sown in F_6 generation was deferred due to poor phenotypic expression. Segregating materials in F_3 generation of 10 crosses were supplied to eight AICRP-G centers for location specific selection and varietal development.

Table 1. Crosses advanced and selections made during the year

Generation	No. of crosses	Crosses/ selections sown	No. of bulks	Single plant selections
F_1	20	20	-	154
F_2	3	30	30	-
F_3	3	3	3	-
F_4	14	14	14	-
F_5	4	10	8	-
F_6	12	31	29	-

Multiplication and maintenance

Fifty-three new advanced breeding lines were multiplied and 43 lines (5 Spanish, 38 Virginia) were maintained. Three advanced breeding lines (PBS 29077, 29078 and 29080) were multiplied for seed enhancement and ICGV 99101 was maintained. Required quantity of seed could be obtained only in PBS 29080 and hence this genotype was proposed for IVT during *kharif* 2007 under AICRP (G) network.

Station trials

Three different yield evaluation trials were conducted under this project. The performance was poor in all the trials because of excessive and untimely rains during the season. In all the trials, observations on flowering, pod and kernel yields were recorded.

Preliminary yield trial of advanced breeding lines

In this trial, 41 genotypes including germplasm lines, cultures from BARC and confectionery cultures from ICRISAT were evaluated along with three checks (GG 20, M 13 and TKG 19A). Because of excessive and untimely rains the performance was very poor and the mean pod yield ranged from 83.5 to 668 kg/ha.

Large-Seeded yield evaluation trial

Twenty seven genotypes along with three checks (GG 20, M 13 and TKG 19A) were evaluated in an RBD. Ten cultures were in 2nd year of evaluation. Data were recorded for SCMR, flowering initiation, days to 50% flowering and plant population at the time of harvest. The performance was very poor and the mean pod yield per plant ranged from less than one gram per plant to 2.9 g/plant. The experimental average yield was only 314.5 kg/ha with a range from 120.5 to 488.7 kg/ha. The 100-seed mass ranged from 34.4 g (PBS 29086) to 56.4 g (PBS 29079B) while the highest value for the check varieties was 44.5 g (M 13) (Table 2). Because of poor season genotypes could not be compared for superiority.

The mean duration for initiation of flowering ranged between 22.3 to 28.3 days while for 50% flowering the mean duration was 25.3 to 32.3 days. The SPAD chlorophyll meter reading, which is an indirect measure of water use efficiency ranged from 28.6 to 36.3. The highest value was recorded in PBS 29067 (36.3) followed by ICGV 90208 (35.5).

Xth International confectionery groundnut varietal trial

Xth International Confectionery Groundnut Varietal Trial, supplied by ICRISAT, with 15 genotypes along with a local check (TPG 41) was taken up in a triple lattice design. Data on flower initiation and 75% flowering were recorded. The performance was very poor and the mean pod yield ranged from 230.7 to 566.3 kg/ha with experimental mean of 398.5 kg/ha. The 100-seed mass ranged between 35.8 g to 58.5 g. The highest seed size was observed in ICGV 00440. Total five genotypes recorded 100-seed mass above 50 g while the check TPG 41 had only 36.7 g (Table 3). Data on other quality parameters were not recorded because of poor expression and yield performance.

Quality evaluation

The produce of 15 advanced breeding lines evaluated along with checks during previous year was subjected to quality analysis for kernel size, shape, seed size uniformity, SMK, testa colour and oil content. The HSM ranged from 32.2 to 59.4 g (PBS 29077) and the genotypes PBS 29077, 29078, 29067 and 29080 had HSM above 50 g while the best check (GG 20) had only 46.3 g. The SMK ranged from as low as 29% to 52% (GG 20) with an overall mean of 40% only, and PBS 29067, 29077, 29052 and 29078 recorded significantly higher values than the check M 13. The oil content in the genotypes ranged from 48.7% (PBS 29052) to 51.8% (PBS 29086) with a mean of 50.9%. Only two genotypes (PBS 29052 and 29073) had oil content below 50%. Majority of the cultures had elongated-oval to oval seed shape with tapering to intermediate shape of the end. Seed size uniformity was highly varying in PBS 23031, 29047, 29071, 29077, and 29086, while PBS 29033, 29035, 29067, 29070, 29078 and 29080 had moderate uniformity (Table 4). Among the 22 genotypes evaluated in the preliminary trial, the HSM ranged from 33.2 to 66.6 g and SMK from 27.4 to 54%. The oil content in the kernels ranged from 49% to 52.8% with an overall mean of 51.3%. Only two genotypes (ICGV 97061 and 97051) recorded oil content less than 50% (Table 5).

Screening for seed coat tolerance of *A. flavus* infection

Selected advanced breeding lines from the yield evaluation trial were subjected to lab screening for seed coat tolerance of *A. flavus* (isolate *AF 111*) infection in collaboration with the Plant Pathology section. The seed colonization ranged from zero to 30%. Among the checks M 13 had zero seed infection and colonization. Genotypes ICGV 89214, ICGV 97061, ICGV 99101, PBS 29035, PBS 29078, ICGV 97051, PBS 29047, PBS 29079A, PBS 29073 and PBS 29069 recorded zero seed colonization though they had 10-20% seed infection.

Table 2. Mean performance of selected genotypes in advanced yield trial

Sr. No.	Genotype	DFI	DF50	Pod yield (g/plant)	Pod yield (kg/ha)	HSM (g)
1	PBS 29082	24.7	28.7	2.93	488.7	49.0
2	ICGV 89214	26.0	29.7	2.67	446.4	48.7
3	PBS 29078	25.0	28.3	2.55	425.6	53.3
4	ICGV 97051	23.7	26.0	2.54	424.2	46.7
5	ICGV 90208	23.7	25.7	2.44	407.6	46.2
6	PBS 29073	25.0	28.3	2.32	386.9	50.8
7	ICGV 90173	23.0	26.0	2.26	377.1	49.4
8	PBS 29080	25.3	29.0	2.20	367.0	50.7
9	ICGV 91099	24.0	26.7	1.70	284.4	46.6
10	ICGV 97040	23.7	26.3	1.64	274.4	46.0
11	PBS 29052	25.0	29.0	1.60	266.9	45.0
12	PBS 29069	27.7	30.3	1.51	252.2	54.0
13	PBS 29079 B	24.7	28.3	1.39	232.3	56.4
14	PBS 29067	23.3	25.3	1.26	210.8	49.0
15	GG 20 (check)	24.0	26.3	1.93	321.7	40.3
16	M 13 (check)	26.3	29.3	2.55	426.6	44.5
17	TKG 19 A (check)	23.0	25.7	1.56	260.9	41.9
	Mean	24.8	28.0	1.88	314.5	45.1
	Sem ±	0.4	0.5	0.27	45.9	1.5

DFI = days to flower initiation; D50 = days to 50% flowering; HSM = 100-seed mass

Table 3. Mean performance of selected genotypes in international trials

Sr. No.	Genotype	DFI	DF75	Pod yield (g/plant)	Pod yield (kg/ha)	HSM (g)
1	ICGV 97079	22.3	24.7	3.18	531.0	47.4
2	ICGV 99102	23.0	25.0	2.74	457.7	52.8
3	ICGV 00380	22.0	24.7	2.94	490.7	39.6
4	ICGV 00391	23.0	25.0	2.04	340.0	54.5
5	ICGV 00429	23.3	25.7	1.75	292.3	50.9
6	ICGV 00440	25.7	29.0	3.39	566.3	58.5
7	ICGV 00441	24.7	27.0	3.16	528.7	46.5
8	ICGV 00451	23.7	26.7	1.77	295.3	45.0
9	ICGV 00456	24.0	27.0	2.81	469.3	57.0
10	TPG 41(check)	24.7	27.3	1.40	234.3	36.7
	Mean	23.4	25.9	2.39	398.5	46.3
	SEm±	0.3	0.2	0.28	46.4	2.9

DFI = days to flower initiation; D75 = days to 75% flowering; HSM = 100-seed mass

Table 4. Quality parameters of selected genotypes evaluated in advanced trial

Sr. No.	Genotype	SO (%)	HSM (g)	SMK (%)	Oil (%)	SHK	SH-End	SSU	Testa colour
1	PBS 29077	66.4	59.4	39.0	51.5	8	2	4	Light tan
2	PBS 29078	65.6	58.5	36.2	51.5	8	3	8	Light tan
3	PBS 29067	62.0	54.8	44.3	50.7	8	3	7	Dark tan
4	PBS 29080	62.2	50.2	50.8	51.0	8	3	6	Light tan
5	PBS 29073	62.0	46.5	34.0	49.0	7	3	7	Light tan
6	PBS 29047	61.6	45.1	40.6	50.3	7	3	4	Dark tan
7	PBS 29035	64.7	44.9	50.8	50.7	8	3	6	Light tan
8	GG 20	68.7	46.3	44.3	51.0	7	3	8	Dark tan
9	M 13	61.3	45.0	43.7	51.0	8	4	2	Tan
10	TKG 19A	62.7	41.6	31.9	60.7	8	3	2	Dark tan
	Mean	61.4	43.9	40.4	50.9				
	CD (5%)	6.6							

[SO- shelling turnover; SHK-Shape of kernel: Score 10 to 1 (Elongated to round); SH-end-Shape of end: Score 5...0 (tapering to blunt); SSU-Seed size uniformity: 10 to 1 (highly uniform to highly varying)]

Table 5. Quality parameters of selected genotypes evaluated in preliminary trial

Sr. No.	Genotype	SO (%)	HSM (g)	SMK (%)	Oil (%)	SHK	SH-End	SSU	Testa colour
1	PBS 29079A	52.6	57.2	35.8	51.0	8	4	5	Tan
2	ICGV 91089	66.4	56.9	42.8	52.2	8	4	3	Dark tan
3	PBS 29079B	55.9	56.4	34.0	50.7	9	3	8	Light tan
4	ICGV 90210	61.8	54.3	46.3	50.5	8	3	5	Purple
5	ICGV 91099	64.7	54.17	41.9	52.0	7	3	6	Tan
6	ICGV 89214	63.9	52.3	32.6	52.2	7	3	5	Tan
7	PBS 29069	44.4	51.0	43.1	51.0	8	4	6	Tan
8	ICGV 97040	64.3	49.8	35.4	51.8	9	4	6	Dark tan
9	ICGV 90308	66.3	48.9	33.9	51.2	8	3	4	Tan
10	ICGV 97061	62.0	48.7	42.6	49.0	7	3	4	Dark tan
11	GG 20	64.6	38.6	39.3	51.7	7	3	7	Dark tan
12	M 13	66.7	44.5	40.5	50.5	8	3	3	Tan
13	TKG 19A	56.8	36.5	32.0	49.3	9	3	2	Dark tan
	Mean	61.3	46.9	36.4	51.3				
	CD (5%)	7.1	15.1	NS	1.8				

PROJECT 14: DIGITAL LIBRARY OF RELEASED VARIETIES, WILD SPECIES, DISEASES, PESTS AND NUTRIENT DISORDERS OF GROUNDNUT IN INDIA

(V. V. SUMANTH KUMAR)

This project was under suspended animation for the period of this report as the PI of the project was on study leave.

PROJECT 15: ECONOMIC ANALYSIS OF GROUNDNUT CULTIVATION IN MAJOR GROUNDNUT GROWING STATES OF INDIA

(G. GOVINDARAJ)

Economic analysis of groundnut cultivation and groundnut based non-oil value-added industries

A complete enumeration of non-oil value-added Industries was done in Junagadh and their production capacity, profitability and employment generation potential was evaluated. The data was collected from the industry owners (salted and *chikki*) using a pre-tested questionnaire. On the basis of installed capacity per day, the salted and *chikki* industries were classified into low capacity (<300 kg/day) and high capacity (>300 kg/day) industries.

Production capacity

All processing industries undergo peak- and off-season phases every year. The study showed that during peak-season (June-February) low capacity *chikki* industries process an average of 300 kg/day during peak season and 150 kg/day during the off-season. The high capacity *chikki* industries process around 800 kg/day and 380 kg/day during peak season and off-season, respectively. On an average, in one year 765 quintals *chikki* are produced by the low capacity industries while 2028 quintals are produced by the high capacity industries (Table 1).

A low capacity salted groundnut industry processes about 225 kg/day during the peak season and 140 kg/day during the off-season. The high capacity salted groundnut industry process about 650 kg/day and 350 kg/day during the peak- and off-seasons, respectively. On an average 590 quintals are produced in a year by the low capacity industry and 1672 quintals were produced by the high capacity salted groundnut industry (Table 1).

Table 1. Average production capacity of the *chikki* and salted groundnut industries in Junagadh

Product and season	Production (kg/day)		Production (kg/year)	
	Low-capacity	High-capacity	Low-capacity	High-capacity
Chikki				
Peak-season	300	800	67500	180000
Off-season	150	380	9000	22800
Total			76500	202800
Salted groundnuts				
Peak-seaon	225	650	50625	146250
Off-season	140	350	8400	21000
Total		59025	167250	

Employment generation

The number of man-hours employed differed between the *chikki* and the salted groundnut industries. A total of 3225 man hours of employment per month was generated by low capacity *chikki* industries during peak season of which, 83.7% was hired labour and 16.3% was family labour. A total of 4200 man-hours employment per month was generated by high capacity industries of which 85.7% was hired labour and 14.3% was family labour. During off-season 960 man hours of employment was generated by low capacity *chikki* industries of which 81.3% was hired labour and 740 man-hours by high capacity *chikki* industries of which 97.3% was hired labour (Table 2).

A total of 1750 man hours per month were employed during peak season by the low capacity salted groundnut industries of which 60% was hired labour and 40% was family labour. The high capacity salted industries employed 2525 man hours per month during peak season of which 65.3% and 34.7% were hired labour and family labour respectively. During the off-season on an average 540 man-hours and 660 man-hours were employed by the low capacity and high capacity industries, respectively (Table 3).

Table 2. Employment generation by groundnut *chikki* industry in Junagadh

Employment generated	Peak season			Off-season		
	HL	FL	Total	HL	FL	Total
Low capacity (<300 kg peak season capacity/day)						
Man hours per month	2700	525	3225	780	180	960
Fraction of total (%)	83.7	16.3	100	81.3	18.8	100
High capacity (>300 kg peak season capacity/day)						
Man hours per month	3600	600	4200	720	20	740
Fraction of total (%)	85.7	14.3	100	97.3	2.7	100

HL-Hired labour; FL-Family labour

Table 3. Employment generated by salted groundnut industry in Junagadh

Employment generated	Peak season			Off-season		
	HL	FL	Total	HL	FL	Total
Low capacity (<300 kg peak season capacity/day)						
Man hours per month	1050	700	1750	300	240	540
Fraction of total (%)	60.0	40.0	100.0	55.6	44.4	100.0
High capacity (>300 kg peak season capacity/day)						
Man hours per month	1650	875	2525	360	300	660
Fraction of total (%)	65.3	34.7	100.0	54.5	45.5	100

HL-Hired labour, FL-Family labour

Capacity utilization

The study on capacity utilization among *chikki* industries revealed that during the peak season 72% capacity was utilized and 28% capacity was un-utilized (excess capacity). During off-season, only 25% of the capacity was utilized. Among high capacity industries the capacity utilization was 80% and 22% during peak- and off-seasons, respectively. The 20% and 70% capacity were left un-utilized during peak and off-season, respectively.

Among salted groundnut industries, only 72% and 30% capacity were utilized during peak and off-season, respectively whereas 28% and 70% capacity were unutilized by Low capacity salted industries. Among High capacity industries, 74% and 28% of full capacity were used during peak and off-season, respectively resulting in less than full utilization. The less capacity utilization during peak season was due to skilled labour un-availability and during off-season less demand hindered full capacity utilization (Table 4).

Table 4. Capacity utilization of *chikki* and salted groundnut industries

Product and season	Capacity utilization (%)			
	Utilized	Unutilized	Utilized	Unutilized
Chikki				
Peak-season	72	28	80	20
Off-season	25	75	22	78
Salted groundnut				
Peak-season	72	28	74	26
Off-season	30	70	28	72

Cost and returns structure of groundnut *Chikki* Industries

The cost and returns structure of low capacity and high capacity *chikki* industries were evaluated. Fixed cost constituted 0.8% of the total cost where as 99.2% was variable cost. Among the variable costs, kernel cost alone was calculated to be 52.2% followed by cost of additives (22%) and (20.8%). During the peak season (June-Feb) the kernel price and prices of additives used in *chikki* production like jaggary, glucose, etc. also fell resulting in low cost of production. Hence, the profitability of the firms was evaluated at varied kernel prices of Rs.30/kg and Rs.35/kg. The total variable cost was Rs.3136/100kg for *chikki* produced in low capacity industries and the return was Rs 3400/100kg (wholesale price) at the kernel price of Rs.30/kg. Hence, a net return of Rs. 239 was obtained per 100 kg of *chikki* produced in low capacity industries. The sensitivity analysis was carried by reducing the kernel price by Rs.5/kg, as during the peak season the price of kernel fell due to fresh arrival of groundnut in the market. The net return per 100 kg of *chikki* was Rs.439 when the kernel prices deflated by Rs.5/kg which is higher vis-à-vis net return at high kernel price. Hence net returns per 100 kg *chikki* were inversely related to kernel price (Table 5a and 5b).

Among the high capacity *chikki* industries, the fixed cost comprised only 0.4% of the total cost while the variable cost comprised 99.6%. Among the variables, the kernels constituted the highest cost of 53.6%, followed by additives (22.6%), packaging and labour (19.2%) and others. The net return was Rs.323 per 100 kg of *chikki* produced. When the price of kernels fell by five rupees and proportional fall in additive prices, as it occurred during the peak season of every year, the profitability increased to 523/100kg.

Table 5a. Cost and returns structure of low capacity *chikki* industries

Component	Cost (Rs.)			
	Kernel @ Rs. 35/kg		Kernel @ Rs. 30/kg	
	Net	Per cent	Net	Per cent
Fixed cost				
Depreciation of building	15.4	0.5	15.4	0.5
Depreciation of machines/utensils	6.9	0.2	6.9	0.2
Interest on fixed capital	2.7	0.1	2.7	0.1
Total fixed cost Rs.	24.9	0.8	24.9	0.8
Variable cost				
Kernel	1650	52.2	1500	50.7
Additive	695	22.0	645	21.8
Fuel + electricity	117	3.7	117	3.9
Packaging + labour	658	20.8	658	22.2
Transportation	16	0.5	16	0.5
Total variable cost Rs.	3135.92	99.2	2935.92	99.2
Total cost Rs.	3160.8	100	2960.8	100
Total returns Rs.	3400		3400	
Net returns Rs.	239.2		439.2	

Table 5b. Cost and returns structure of high-capacity *chikki* industries

Component	Cost (Rs.)			
	Kernel @ Rs. 35/kg		Kernel @ Rs. 30/kg	
	Net	Per cent	Net	Per cent
Fixed cost				
Depreciation of building	7.6	0.2	7.6	0.3
Depreciation of machines/utensils		0.1	4.1	0.1
Interest on fixed capital	1.4	0.0	1.4	0.0
Total fixed cost	13.1	0.4	13.1	0.5
Variable cost				
Kernel	1650	53.6	1500	52.1
Additive	695	22.6	645	22.4
Fuel + electricity	107	3.5	107	3.7
Packaging + labour	592	19.2	592	20.6
Transportation	20	0.7	20	0.7
Total variable cost	3063.67	99.6	2863.67	99.5
Total cost	3076.8	100.0	2876.8	100.0
Total returns	3400		3400	
Net returns	323.2		523.2	

The cost and returns structure of the salted groundnut industries were also evaluated. Among the lo capacity salted groundnut industries, the total cost was Rs.4385.8/q of which 99.6% was variable and 0.4% w fixed. Among the variable cost the kernels constituted the 91.2 % hence the cost of kernels was inversely rela to profits of salted industries. Similarly when sensitivity analysis was carried out by reducing the kernel price five rupees, the net returns per q processed produce increased from Rs. 614 to Rs.1114 (Table 6a).

The net returns generated by high capacity salted industries were Rs. 592/q at kernel price of Rs. 40 which increased to Rs.1092 at kernel price of Rs. 35/kg (Table 6b).

Table 6a. Cost and returns structure of low-capacity salted groundnut industries

Component	Cost (Rs.)			
	Kernel @ Rs. 40/kg		Kernel @Rs. 35/kg	
	Net	Per cent	Net	Per cent
Fixed cost				
Depreciation of building	11.1	0.3	11.1	0.3
Dep. cost of Machines/utensils	3.3	0.1	3.3	0.1
Interest on fixed capital	1.7	0.04	1.7	0.04
Total fixed cost	16.1	0.4	16.1	0.4
Variable cost				
Kernel	4000	91.2	3500	90.1
Additive	100	2.3	100	2.6
Fuel + electricity	87.5	2.0	87.5	2.3
Pack + labour	130	3.0	130	3.3
Transportation	20	0.5	20	0.5
Total variable cost	4369.7	99.6	3869.7	99.6
Total cost	4385.8	100.0	3885.8	100.0
Total returns	5000		5000	
Net returns	614.2		1114.2	

Table 6b. Cost and returns structure of high-capacity salted groundnut industries

Component	Cost (Rs.)			
	Kernel @ Rs. 40/kg		Kernel @ Rs. 35/kg	
	Net	Per cent	Net	Per cent
Fixed cost				
Dep. cost of Building	7.5	0.2	7.5	0.2
Dep. cost of Machines/utensils	1.6	0.01	1.6	0.04
Interest on fixed capital	1.1	0.03	1.1	0.02
Total fixed cost	10.2	0.2	10.2	0.3
Variable cost				
Kernel	4000	90.8	3500	89.6
Additives	100	2.3	100	2.6
Fuel + electricity	87.5	2.0	87.5	2.2
Packaging + labour	190	4.3	190	4.9
Transportation	20	0.5	20	0.5
Total variable cost	4397.5	99.8	3897.5	99.7
Total cost	4407.6	100.0	3907.6	100
Total returns	5000		5000	
Net returns	592.4		1092.4	

PROJECT 16: MULTIPLICATION AND UTILIZATION OF WILD *ARACHIS* GENE POOL FOR IMPROVEMENT OF GROUNDNUT

(S. K. BERA, RADHAKRISHNAN T., CHUNI LAL, VINOD KUMAR AND T. V. PRASAD)

Development of interspecific hybrids and back crossing

Interspecific hybrids developed in the previous year and wild *Arachis* accessions possessing desirable traits were used for back crossing and direct crossing. During rainy season 10 BC_2, 5 BC_1, 5 interspecific and 2 intervarietal crosses (Table 1) were made in field conditions. Not only the number of pollinations attempted but also the success rate was low due to heavy and prolonged rains during peak flowering stage. The probable cross pods were collected at harvest and grown in summer season for isolation of hybrids and their further utilization.

Table 1. Hybridization undertaken during rainy season

Cross combination	Number of pollinations attempted	Number of cross-pods harvested	Number of kernels obtained
BC_2			
Chico /// GG 2 // J11 / *A. kempfmarcadoi*	219	32	49
Chico /// GG 2 // J11/ *A. correntina*	320	26	45
Chico /// GG2 // J11 / *A. duranensis*	278	27	37
Chico /// GG2 // J11 / *A. kretschmeri*	279	56	85
Chico /// GG2 // J11 / *A. stenosperma*	301	30	42
TAG 24 /// GG2 // J11 / *A. correntina*	296	20	29
TAG 24 /// GG2 // J11 / *A. duranensis*	362	37	50
TAG 24 /// GG2 // J11 / *A. kretschmeri*	452	58	70
TAG 24 /// GG2 // J11 / *A. correntina*	386	42	60
TAG 24 /// GG2 // J11 / *A. stenosperma*	519	28	39
BC_1			
GG2 // J11 / *A. digoi* (NRCG11781)	257	14	25
GG2 // J11 / *A. batizocoi* (NRCG12030)	390	21	28
GG2 // J11 / *A. monticola* (NRCG11800)	440	39	65
GG2 // J11 / *A. pusilla* (ICG8131)	450	61	103
GG2 // J11/ *A. kretschmeri* (NRCG12029)	373	48	70
Interspecific			
J11 / NRCG14821	25	8	13
J11 / NRCG11781	29	5	10
J11 / NRCG12037	24	25	44
J11 / NRCG11800	42	17	24
J11 / NRCG11785	17	14	23
Intervarietal			
OG 52-1 / NRCG CS 19	296	34	49
ICGV 86590 / NRCG CS 19	162	20	25

Probable hybrid pods of six interspecific and three intervarietal crosses were grown during rainy season for confirmation. Hybrids could be identified and tagged from all crosses except J11 x *A. rigoni* (Table 2). Hybridization was not successful in J11 x *A. rigoni*, an indication that *A. rigoni* may be cross incompatible. Hybrids were confirmed cytologically and characterized for physio-morphological traits. Colchicine treatment was given to each hybrid immediately after identification in field conditions. Pods were harvested from the fertile F_1 hybrids for further use. Similarly, half of the cross pods of intervarietal crosses (Table 2) were sown to develop F_2 generation and screening. The parents, F_1 and F_2 generations were screened simultaneously for resistance to stem rot pathogen in epiphytotic conditions.

Table 2. Cross wise number of pollinations made and hybrids isolated

Cross	Number of pollinations attempted	Number of probable cross harvested	Number of hybrids isolated
J11 x *A. diogoi* (NRCG 11781)	574	300	06
J11 x *A. batizocoi* (NRCG12030)	539	353	10 (normal) 13 (abnormal)
J11 x *A. monticola* (NRCG11800)	603	430	08
J11 x *A. pusilla* (ICG 8131)	592	360	41
J11 x *A. kretschmeri* (NRCG 12029)	608	340	28
J11 x *A. regoni* (NRCG12032)	601	450	Nil
OG 52-1 x NRCG CS 19	257	155	
ICGV 86590 x NRCG CS 19	473	250	
Puckered x crinkled	612	200	27 crinkled

Table 3. Advancement of segregating lines

Cross	Number of lines sown	
	Single plant	Bulk
J11x *A. duranensis*	32	23
(J 11 / *A. duranensis*)// GG 2	36	-
6x *A. hypogaea x A. cardenasii*	-	1
J 11 x *A. correntina* F_2	-	1
J 11 x *A. oteroi* F_2	-	1
J 11 x *A. diogoi* F_2	-	1
J 11 x *A. helodes* F_2	-	1
J 11 x *A. kretschmeri* F_2	-	1
J 11 x *A. kretschmeri* F_3	11	1
J 11 x *A. duranensis* F_3	-	1
J 11 x *A. correntina* F_2	-	1
VRI 4 x *A. correntina* F_2	-	1
White-flower x crinkled-leaf		24
White-testa x crinkled-leaf		16
Red-testa x crinkled-leaf		7
ICGL 5 x crinkled-leaf		3
Total	79	83

Advancement of segregating lines

Segregating progenies of 12 interspecific and 4 intervarietal crosses comprising 79 single plant selections and 33 bulk selections (F_4 to F_7 generations) were sown for generation advancement during rainy season. Each progeny was sown in a 3 to 10 rows of 3 m each as per availability of seeds (Table 3). However, progenies were advanced to next generation in bulk because of poor pod setting due to excess and prolonged rainfall in Junagadh.

Sixty-eight segregating lines of five crosses developed for studies on inheritance were sown for generation advancement during summer season. Segregating ratios of F_1 and F_2 generations revealed that 'crinkled-leaf and 'white-testa' versus 'crinkled-leaf' and 'red-testa' segregated independently and are monogenic in nature. A total of seventy lines were advanced in the field to F_4 generation on the basis of agronomic traits (Table 4). Two distinct mutants ('crinkled-leaf and white-testa' and 'crinkled-leaf and red-testa') were isolated and fixed. These two near isogenic lines would be evaluated and used for further genetic studies.

Figure 1. Crinkled-leaf red-testa and crinkled-leaf white-testa isogenic lines

Table 4. Cross wise number of lines advanced to next generation

Cross	No. of selections sown	No. of selections made
Purple-tan x dark-red	15	15
White-flower x crinkled-leaf	20	20
White-testa x crinkled-leaf	17	17
Red-testa x crinkled-leaf	13	15
ICGL 5 x crinkled-leaf	03	03
Total	68	70

Evaluation of large-seeded groundnut genotypes

Advanced interspecific breeding lines were screened in augmented design along with checks over three seasons at NRCG. Thirty-three selected advanced lines recorded higher 100-kernel mass than the checks. All these 33 genotypes were further evaluated for confirmation of large kernel character at two locations (KVK, Mundra and NRCG, Junagadh) during rainy season. These genotypes along with three checks (BAU13, TKG19A and M13) were sown in RBD with three replications and recommended management practices were followed for the experiment at both the locations. Observations on pod yield, shelling turnover, 100 kernel weight and SMK were recorded at harvest. TKG19A recorded higher pod yield/plant (29 g), 100-kernel weight (50 g) and the shelling % (63), except the SMK % (67) than the corresponding values for the checks. However, genotypes did not express their full potential for large kernel size due to poor soils at the KVK farm, while only 2 genotypes *viz*., CS 148 and CS 281 recorded significantly higher 100-kernel weight (60 g and 66 g, respectively) than the best check TKG19A (50 g) (Table 5).

Table 5. Evaluation of selected large-seeded groundnut genotypes (CS lines) along with check varieties at KVK, Mundra

Genotype	PY (g/plant)	Shelling turnover (%)	HSM (g)	SMK (%)	Genotype	PY (g/plant)	Shelling turnover (%)	HSM (g)	SMK (%)
CS lines					*CS lines*				
CS 13	19	64	36	46	CS 165	16	56	37	80
CS 18	19	54	39	73	CS 169	13	63	41	84
CS 51	17	66	37	84	CS 170	29	52	29	80
CS 82	14	65	36	84	CS 188	17	72	44	71
CS 89	20	60	38	76	CS 219	21	63	46	82
CS 97	20	60	41	76	CS 241	18	63	46	80
CS 103	18	63	38	91	CS 249	14	40	39	71
CS 115	19	57	36	75	CS 250	17	60	43	85
CS 116	20	67	41	91	CS 252	20	46	28	76
CS 122	19	54	43	62	CS 256	18	61	34	85
CS 123	18	52	40	60	CS 268	13	71	34	75
CS 126	20	58	43	79	CS 281	14	64	66	85
CS 130	10	64	44	85	CS 285	29	56	47	79
CS 132	20	51	33	75	*Check*				
CS 138	12	55	38	83	BAU 13	17	53	47	81
CS 145	13	57	39	68	TKG 19A	29	63	50	67
CS 148	17	68	60	64	M 13	27	56	43	65
CS 150	16	50	31	71	Mean	18	58	40	76
CS 159	23	41	24	60	SEm±	5	7	8	10
CS 164	8	58	44	78	CV (%)	26.5	12.8	19.7	12.8

PY = pod yield; HSM = hundred seed mass; and SMK = sound mature kernels

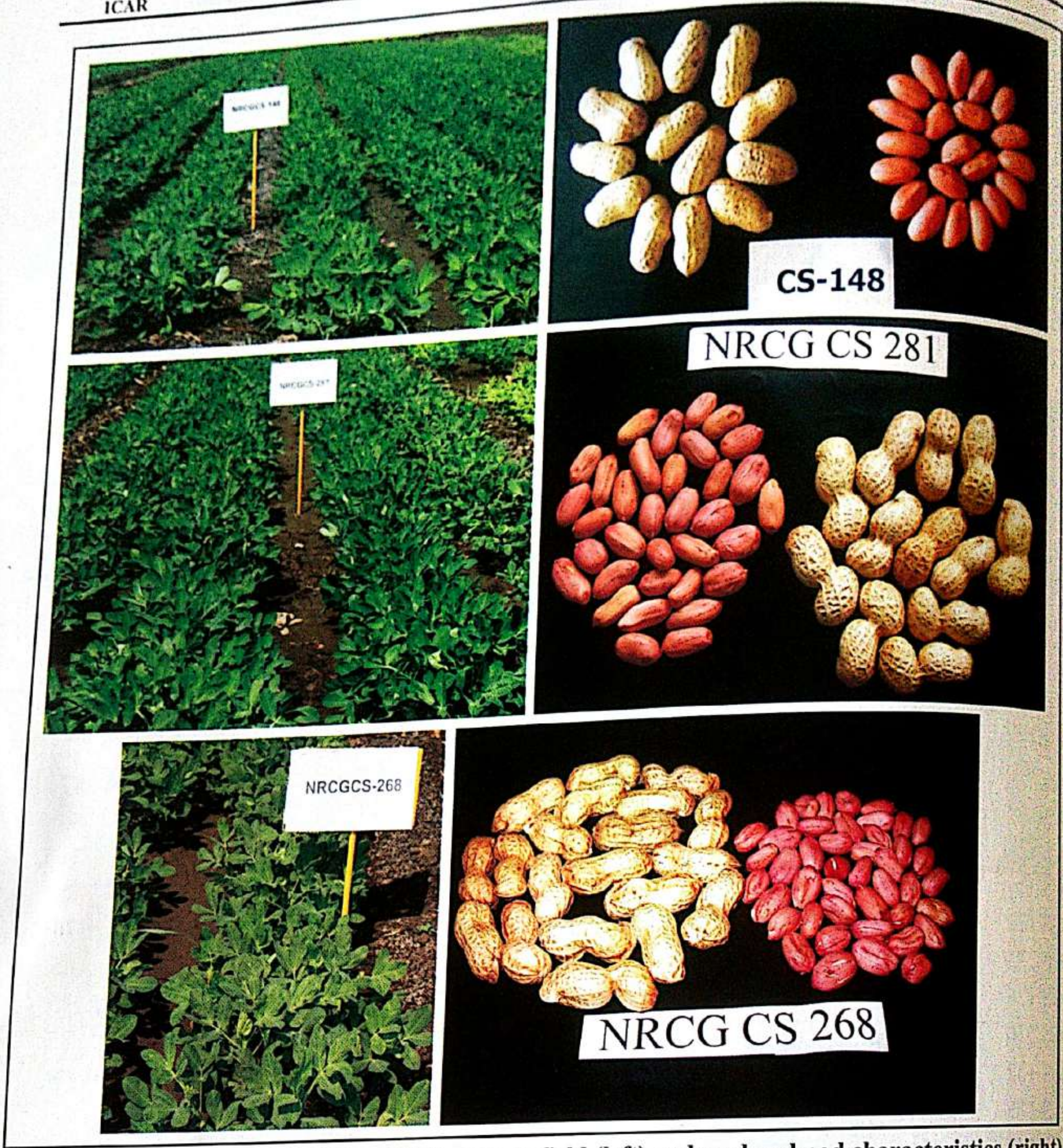

Figure 2. NRCG CS lines 148, 281 and 268: crop in field (left) and seed and pod characteristics (right)

Evaluation of advanced breeding lines for yield

Freshly generated 120 advanced breeding lines were sown along with checks in augmented design for preliminary evaluation during rainy season. Similarly, 29 selected advanced genotypes were sown in RBD with three replications. Recommended spacing and agronomic practices were followed for both the experiments. Genotypes recorded poor pod yield due to heavy rains during crop season and water stagnation in the field (Table 6).

Table 6. Evaluation of selected advanced lines

Genotype	Pod yield (g/plant)	Genotype	Pod yield (g/plant)
NRCG CS 153	2.2	NRCG CS 200	1.5
Drpv 17	1.4	NRCG CS 114	1.4
NRCG CS 2	1.5	NRCG CS 82	2.0
NRCG CS 87	1.8	NRCG CS 98	1.0
NRCG CS 184	1.8	NRCG CS 6	1.3
NRCG CS 206	1.8	NRCG CS 36	1.9
NRCG CS 178	0.8	NRCG CS 175	1.6
NRCG CS 163	1.2	NRCG CS 170	1.5
NRCG CS 168	1.4	NRCG CS 53	1.7
NRCG CS 158	1.9	NRCG CS 148	2.4
NRCG CS 229	1.9	NRCG CS 221	1.3
NRCG CS 147	1.3	NRCG CS 83	2.1
NRCG CS 135	1.9	Drpv18	1.6
NRCG CS 93	1.2	NRCG CS 1	1.3
NRCG CS 180	2.1	GG 20 (check)	2.0

This experiment was repeated during summer season. Genotypes were assessed for pod yield, shelling%, SMK%, and 100-kernel mass (HKM) at harvest. Sixteen genotypes *viz.*, NRCG CS nos 237, 240, 241, 242, 251, 259, 268, 281, 287, 289, 291, 296, 297, 312, 322, 347 recorded higher yield; thirteen genotypes *viz.*, NRCG CS nos.' 240, 248, 270, 287, 302, 306, 315, 332, 336, 342, 345, 346, 350 performed better for shelling (%); fifty-one genotypes performed better for SMK (%), and seven genotypes *viz.*, NRCG CS nos.' 255, 268, 269, 281, 283, 285, 313 performed better for HMK over the best check.

Screening of wild *Arachis* species and advanced lines against traits associated with drought

Specific Leaf Area (SLA) has been established as one of the parameters for assessing the performance of genotypes under drought conditions and is being used in drought resistant breeding programme. SLA was recorded from 100 wild *Arachis* accessions and 357 advanced interspecific lines from the field grown plants to assess and compare existing variability in both populations. Initial observations revealed similar distribution indicating coexistence of similar variability in both the populations (Table 7 and Figure 3). The variability in SLA, available in the cultivated background may be exploited rather than looking for variability in SLA in the wild species which is difficult to transfer.

Table 7. Genetic parameters for SLA in cultivated and wild populations

Variability	Advanced lines (357)	Wild accession (101)
Mean	240.6	229.2
Max	423.9	466.2
Min	127.1	114.6
SEm±	63.1	62.98
CV %	24.84	27.48

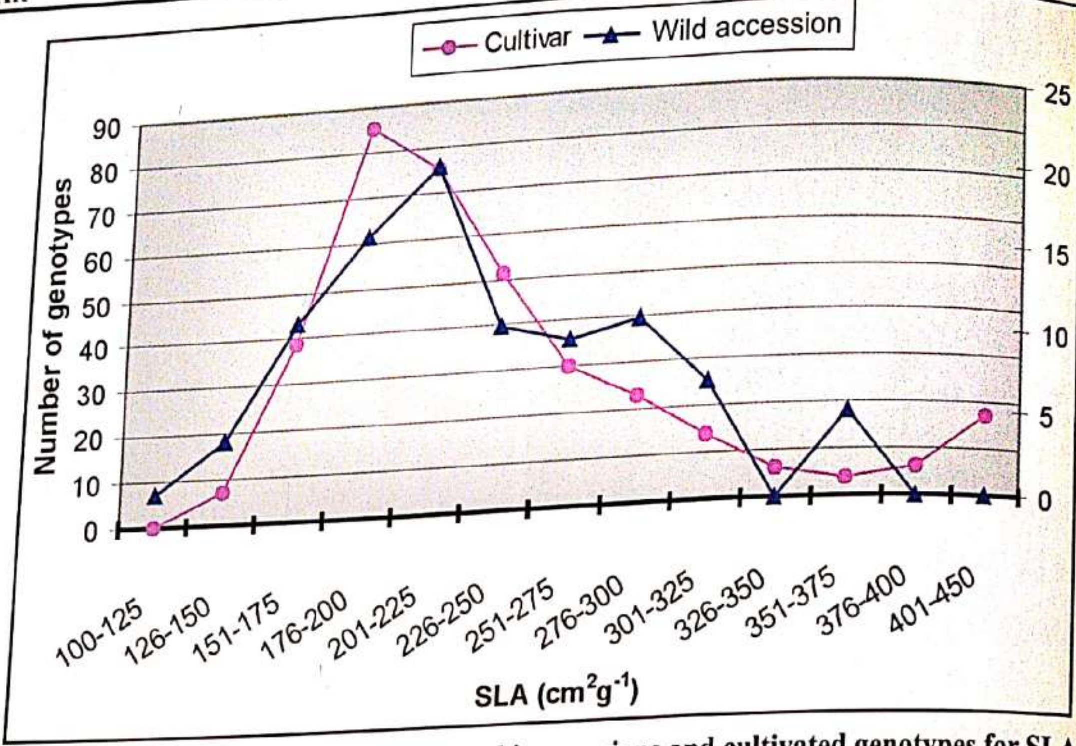

Figure 3. Distribution curve of wild *Arachis* accessions and cultivated genotypes for SLA

Induction of variability through chemical mutagenesis

Kernels of cv. GG 2 were treated with different dosages of three chemical mutagens *viz.,* Ethyl Methane Sulphonate, Colchicine and Cloramphenicol. Desirable mutants were selected and advanced on the basis of agronomic traits. Fifty lines from EMS treatment (0.3. 0.4, 0.5, 0.6 and 0.7%), 4 lines from colchicine treatments (0.3. 0.4, 0.5, 0.6 and 0.7%) and 55 lines from cloramphenicol treatments (0.3. 0.4, 0.5, 0.6 and 0.7%) were sown in the field during rainy season, for fixation. However, mutants were harvested in progeny bulk without any observation due to poor crop season.

Introgression of stem rot resistance to cultivated groundnut

Cultivar GG 20 is an elite groundnut variety for Gujarat state but farmers are gradually replacing it due to susceptibility to stem rot disease. Cultivar GG 20 was crossed with NRCGCS 19, a stem rot resistant line registered by the NRCG, in reciprocal to introgress resistance into GG 20. A total of 405 single plant F_1 progenies were sown in sick plot condition. However, progenies could not be screened due to heavy rain and harvested in bulk.

Testing of selected lines against foliar diseases and stem rot at RRS, Raichur and CRS, Aliyarnagar

Reactions to late leaf spot (LLS), rust, peanut bud necrosis disease (PBND) and stem rot at RRS, Raichur

Sixty one selected entries (Table 8) supplied to RRS, Raichur were screened against major diseases of groundnut along with 5 checks. Late leaf spot ranged between 2 to 8 grades. Twenty entries *viz.,* NRCG CS nos.' 19, 60, 70, 72, 73, 77, 78, 85, 86, 107, 124, 186, 192, 196, 207, 210, 222, 257, R 2001-3 and GPBD 4 recorded between 3 to 4 grades of late leaf spot against local check (Table 8). Further, PBND incidence ranged between 2.9 (R 2001-1) to 40% (CS 199). Among them, three entries *viz.,* CS 85, R 2001-1 and R 2001-3 were highly resistant to PBND recording less than 5% incidence against 46% in susceptible check. Stem rot incidence ranged between 2.6 (CS 192) to 31.3% (CS 117). Further, eight entries *viz.*, NRCG CS nos.' 15, 121, 127, 180, 185, 192, 195 and 196 were found promising by recording less than 5% against 22.0 % in KRG 1.

Table 8. Reactions of genotype to LLS, rust, PBND and stem rot

Genotype	LLS (1-9 scale)	Rust (1-9 scale)	PBND (%)	Stem rot (%)	Genotype	LLS (1-9 scale)	Rust (1-9 scale)	PBND (%)	Stem rot (%)
CS lines					*CS lines*				
CS 12	4	3	14.7	5.9	CS 169	4	3	26.3	10.5
CS 15	5	2	8.8	2.9	CS 171	4	4	47.1	17.6
CS 19	3	3	8.3	12.5	CS 176	4	3	8.7	13.0
CS 20	4	3	9.1	6.1	CS 178	4	3	15.2	6.1
CS 21	4	3	13.5	5.4	CS 180	4	2	5.9	2.9
CS 36	5	4	26.7	6.7	CS 185	5	4	20.8	4.2
CS 37	5	4	9.1	13.6	CS 186	3	3	29.2	12.5
CS 38	5	3	14.3	10.7	CS 187	4	3	10.8	8.1
CS 46	5	3	12.9	6.5	CS 192	3	3	7.9	2.6
CS 54	5	3	17.9	10.7	CS 195	4	3	11.9	4.8
CS 58	4	3	29.4	23.5	CS 196	3	3	5.6	2.8
CS 60	3	4	14.3	9.5	CS 197	5	4	22.2	14.8
CS 70	2	4	17.6	5.9	CS 199	4	4	40.0	16.0
CS 72	2	2	15.4	11.5	CS 203	5	4	21.7	13.0
CS 73	2	3	16.0	20.0	CS 205	5	4	25.0	15.0
CS 74	4	2	20.0	13.3	CS 207	3	3	28.0	12.0
CS 77	2	1	11.4	8.6	CS 210	3	2	18.2	9.1
CS 78	3	2	11.9	7.1	CS 212	5	4	21.7	13.0
CS 81	4	3	7.1	10.7	CS 213	6	3	18.2	12.1
CS 83	4	2	3.4	10.3	CS 222	3	2	12.5	7.5
CS 85	3	3	4.0	8.0	CS 234	4	4	5.9	11.8
CS 86	3	3	11.1	7.4	CS 252	5	4	20.0	8.0
CS 87	4	3	10.0	20.0	CS 257	3	3	30.0	20.0
CS 92	5	4	9.7	6.5	GG 2	5	4	19.2	7.7
CS 95	6	4	27.8	22.2	GG 20	4	4	15.8	10.5
CS 96	6	4	26.3	10.5	R 8808	4	3	13.3	11.1
CS 105	5	4	10.3	6.9	R 2001-1	4	4	2.9	5.7
CS 107	3	3	7.7	7.7	R 2001-2	4	3	7.1	7.1
CS 112	5	4	11.4	11.4	R 2001-3	3	2	3.3	6.7
CS 113	5	4	15.8	7.0	KRG 1	5	4	20.0	6.7
CS 117	6	3	18.8	31.3	R 9251	5	4	5.7	5.7
CS 118	5	3	7.1	10.7	GPBD 4	3	2	22.2	8.9
CS 121	5	3	7.4	3.7	TMV 2	8	5	16.0	28.0
CS 123	5	3	32.0	8.0	TGLPS 3	5	4	5.3	7.9
CS 124	3	2	8.7	13.0	*Local check*	8	5	46	22.0
CS 127	5	4	8.3	4.2					

Reaction to LLS and rust at ARS, Aliyarnagar

Sixty-one selected lines (Table 9) supplied to ARS, Aliyarnagar were screened for resistance to major diseases of groundnut along with checks. Only one groundnut line *viz.*, NRCG CS105 was found to be resistant to rust (3.0 grade) and late leaf spot disease (nil incidence). CS197 showed moderately susceptible reaction to rust (5.0 grade). The entries *viz.*, NRCG CS 77 (4.5 grade) and NRCG CS 222 (5.0 grade) were found to be moderately susceptible to late leaf spot disease.

Table 9. Reaction of selected genotypes to late leaf spot and rust at ARS, Aliyarnagar

Genotype	Rust (1-9 scale)	LLS (1-9 scale)	Genotype	Rust (1-9 scale)	LLS (1-9 scale)
CS lines			*CS lines*		
CS 12	7.0	7.3	CS 118	8.0	8.5
CS 15	8.2	8.8	CS 121	7.0	5.5
CS 19	7.3	8.4	CS 123	8.0	8.4
CS 20	7.0	7.5	CS 124	7.5	5.6
CS 21	8.3	8.4	CS 127	8.3	8.5
CS 36	7.5	5.5	CS 169	8.5	8.0
CS 37	7.4	7.6	CS 171	8.5	8.0
CS 38	7.5	7.5	CS 176	8.0	8.5
CS 46	7.8	7.0	CS 178	8.0	7.0
CS 54	8.0	8.0	CS 180	7.0	6.5
CS 58	8.5	8.0	CS 185	7.5	6.5
CS 60	7.6	7.5	CS 186	7.4	7.5
CS 70	8.2	8.5	CS 187	7.0	7.5
CS 72	8.4	6.6	CS 192	6.5	5.5
CS 73	7.5	7.7	CS 195	6.6	5.8
CS 74	7.5	6.6	CS 196	6.7	5.5
CS 77	7.4	4.5	CS 197	5.0	5.5
CS 78	6.5	6.0	CS 199	8.5	8.0
CS 81	7.0	5.5	CS 203	8.0	8.3
CS 83	7.0	6.8	CS 205	7.5	6.5
CS 85	7.0	7.4	CS 207	8.3	8.5
CS 86	7.3	7.7	CS 210	7.7	6.5
CS 87	9.0	7.0	CS 212	8.0	8.5
CS 92	9.0	8.0	CS 213	8.8	8.0
CS 95	8.3	8.8	CS 222	5.5	5.0
CS 96	8.0	8.0	CS 234	7.5	6.0
CS 105	3.0	0.0	CS 252	7.5	6.0
CS 107	7.3	7.7	CS 257	7.5	7.0
CS 112	7.4	7.8	*Check*		
CS 113	6.4	5.5	GG 2	8.0	8.0
CS 117	8.3	8.5	GG 20	7.0	6.0

Standardization of protocols for regeneration from leaf explants

Seed multiplication rate in wild *Arachis* sp. is very limited. A few species propagate through rhizome and do not produce any seed. *In vitro* screening of wild *Arachis* species against biotic stress needs efficient regeneration protocols from vegetative explants. Hence, experiments were carried out to standardize protocols for regeneration from leaf directly or through callogenesis. Different combinations of auxins (PIC, picloram; NAA, naphthalene acetic acid; and 2,4-dichlorophenoxy acetic acid, 2,4-D) and cytokinins (BAP, benzyl adenine and TDZ) were tested for callogenesis, and regeneration from leaf of a rhizomatous wild *Arachis* species. Among three auxins tested, PIC produced higher percentage of callus than NAA and 2,4-D in all the concentrations tested. PIC recorded more callogenesis in combination with BAP, than sole PIC and in combination with TDZ (Figure 4). Callogenesis also increased in combination of NAA + BAP and NAA+TDZ than sole NAA. Similar trend was also recorded in combination of 2,4-D+BAP and 2,4-D+TDZ than sole 2,4-D. However, BAP produced more callogenesis in combination of either of the auxins than TDZ, in groundnut (Table 10, 11&12). Callus was sub-cultured in respective medium after 15 days and sporadic regeneration (10-14%) from leaf callus was observed (Table 13 and Figure 5) which would be further confirmed.

Table 10. Callogenesis in PIC alone and in combination with BAP and TDZ

Conc. of PIC (mg/L)	Callogenesis (%)						
	PIC	Conc. of BAP in combination with PIC			Conc. of TDZ in combination with PIC		
		(0.5mg/L)	(1.0mg/L)	(1.5mg/L)	(0.5mg/L)	(1.0mg/L)	(1.5mg/L)
0.5	86.1	100.0	100.0	100.0	100.0	95.0	95.0
1.0	87.2	100.0	100.0	100.0	90.0	89.5	100.0
1.5	89.0	95.0	100.0	100.0	95.0	95.0	70.0
2.0	95.0	100.0	100.0	100.0	90.0	85.0	60.0
2.5	88.1	100.0	100.0	100.0	100.0	65.0	64.7
3.0	96.6	100.0	100.0	100.0	95.0	90.0	70.0
3.5	81.1	100.0	100.0	100.0	90.0	85.0	57.9
4.0	72.1	100.0	100.0	100.0	90.0	85.0	75.0
4.5	73.4	100.0	100.0	100.0	100.0	85.0	65.0
5.0	91.2	95.0	100.0	100.0	95.0	75.0	70.0

Table 11. Callogenesis in NAA and in combination of BAP and TDZ

NAA Conc.	NAA	NAA+BAP (0.5mg/L)	NAA+BAP (1.0mg/L)	NAA+BAP (1.5mg/L)	NAA+TDZ (0.5mg/L)	NAA+TDZ (1.0mg/L)	NAA+TDZ (1.5mg/L)
0.5mg	0.0	90.0	100.0	75.0	40.0	100.0	47.4
1.0mg	12.5	94.7	100.0	100.0	70.0	100.0	65.0
1.5mg	16.7	100.0	100.0	100.0	80.0	76.5	72.2
2.0mg	15.5	90.0	100.0	100.0	45.0	80.0	72.2
2.5mg	36.1	85.0	100.0	94.7	60.0	82.4	90.0
3.0mg	18.3	100.0	100.0	95.0	85.0	83.3	90.0
3.5mg	33.3	94.4	100.0	85.0	85.0	52.6	93.8
4.0mg	36.7	100.0	95.0	80.0	75.0	85.0	95.0
4.5mg	25.0	100.0	90.0	68.8	60.0	75.0	68.4
5.0mg	27.8	75.0	89.5	89.5	75.0	45.0	55.6

Table 12. Callogenesis in 2, 4-D and in combination of BAP and TDZ

2,4-D Con.	2,4-D	2,4-D+BAP (0.5mg/L)	2,4-D+BAP (1.0mg/L)	2,4-D+BAP (1.5mg/L)	2,4-D+TDZ (0.5mg/L)	2,4-D+TDZ (1.0mg/L)	2,4-D+TDZ (1.5mg/L)
0.5mg	9.2	80.0	100.0	100.0	63.2	95.0	83.3
1.0mg	6.8	65.0	95.0	100.0	65.0	90.0	100.0
1.5mg	8.9	80.0	100.0	100.0	60.0	80.0	76.5
2.0mg	5.6	70.0	100.0	100.0	75.0	95.0	75.0
2.5mg	8.3	83.3	95.0	100.0	89.5	62.5	70.6
3.0mg	6.7	25.0	100.0	100.0	62.5	70.0	94.7
3.5mg	6.1	50.0	100.0	100.0	70.0	90.0	72.2
4.0mg	4.8	80.0	100.0	100.0	75.0	80.0	83.3
4.5mg	10.0	40.0	94.7	95.0	84.2	88.9	58.3
5.0mg	10.0	70.0	100.0	85.0		75.0	83.3

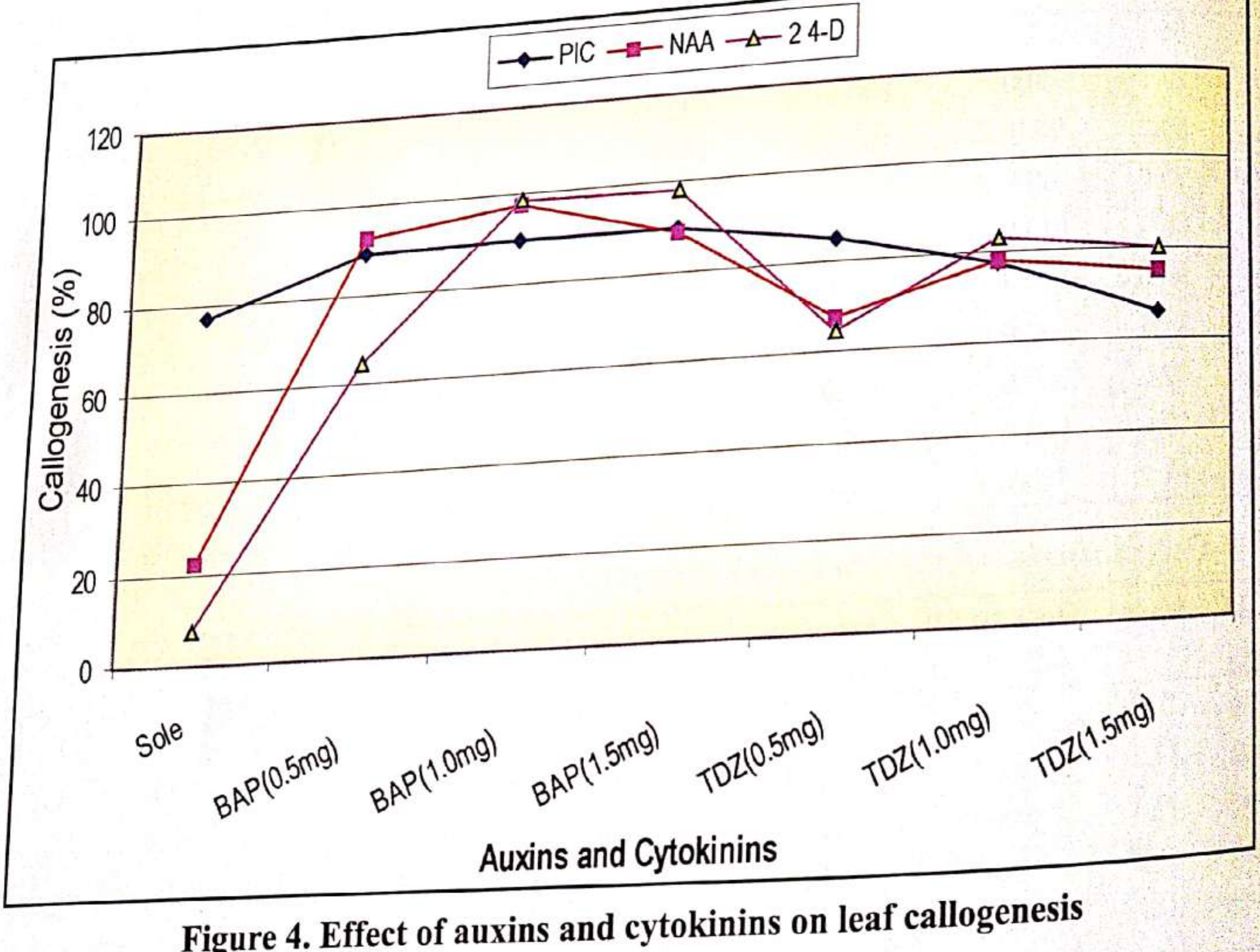

Figure 4. Effect of auxins and cytokinins on leaf callogenesis

Table 13. Regeneration from leaf callus

Conc. of auxin (PIC/NAA/2,4-D) (mg/L)	Shoot regeneration (number/callus)								
	Conc. of TDZ in combination with PIC			Conc. of TDZ in combination with NAA			Conc. of TDZ in combination with 2,4-D		
	(0.3mg/L)	(1.0mg/L)	(3.0mg/L)	(0.3mg/L)	(1.0mg/L)	(3.0mg/L)	(0.3mg/L)	(1.0mg/L)	(3.0mg/L)
0.5	Not sub cultured	Not sub cultured	Not sub cultured	0	0	0	0	0	0
1.0				0	0	0	0	0	0
1.5				11 (30DAC)	0	0	10 (30DAC)	0	0
2.0				0	0	0	0	0	0
2.5				0	0	0	0	0	0
3.0				14 (30DAC)	0	0	10 (30DAC)	0	0
3.5				0	0	0	0	10 (40DAC)	0
4.0				0	0	0	0	0	0
4.5				0	0	0	0	0	10 (35DAC)
5.0				12 (30DAC)	0	0	0	0	0

DAC = days after culture

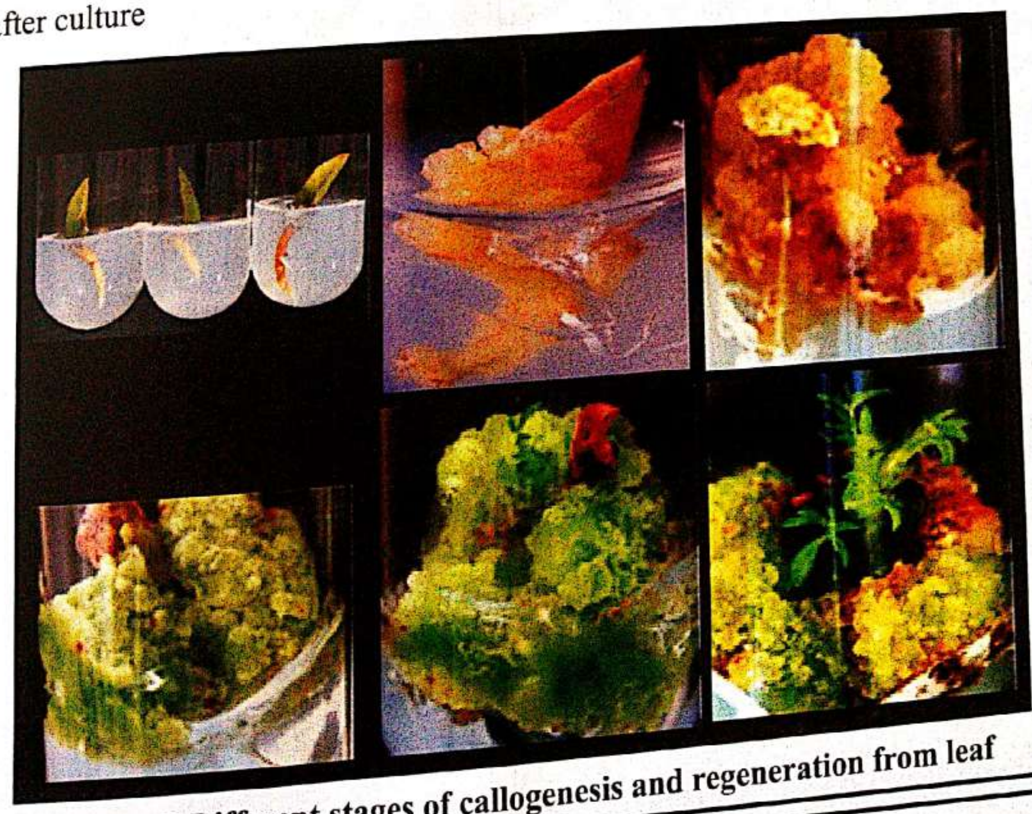

Figure 5. Different stages of callogenesis and regeneration from leaf

PREVENTION AND MANAGEMENT OF MYCOTOXIN CONTAMINATION IN COMMERCIALLY IMPORTANT AGRICULTURAL COMMODITIES

(VINOD KUMAR AND RADHAKRISHNAN T.)

FUNDING AGENCY: ICAR AP CESS FUND

Screening of genotypes for resistance to *A. flavus*

In vitro conditions

A total of 25 genotypes/cultivars were screened for dry seed resistance against *A. flavus* under laboratory conditions by artificially inoculating the seeds with the most virulent isolate of *Aspergillus flavus* (NRCG 01 111). Four genotypes *viz.* PBS 29080, PBS 29047, PBS 29079A and ICGV 99101 showed promise against *in-vitro* seed colonization recording ≤ 10% seed infection and zero seed colonization.

Under sick plot conditions

A total of sixty five advanced breeding lines of NRCG and cultivars, showing promising resistance to seed infection against *A. flavus* under laboratory conditions, including susceptible (GG 20) and resistant checks (J11), were evaluated in augmented block design under artificially inoculated sick plot conditions for tolerance/resistance against *A. flavus* infection during summer 2006. The soil was inoculated thrice with the most virulent isolate of *A. flavus,* AF 111, at sowing, flowering and at 90 days of crop. Observations were recorded on incidence of aflaroot and pod samples were taken. They were analysed for seed infection by *A. flavus* and aflatoxin contamination levels. The infection level varied between 0-4.5 percent. The samples were categorized in four lots *viz.* bulk, large sized, medium, and small sized pods. The aflatoxin contamination ranged from 0.00 to 624.44 μg kg^{-1}. Thirteen genotypes *viz.*, BAU 13, ICGS1, NRCG CS nos.'-15, 76, 272, 306, 312, 334, 343, 350, 352 and OG 52-1, TAG 26 showed promise against aflatoxin contamination during summer 2006 showing tolerance to *A. flavus* infection and subsequent aflatoxin contamination.

During *kharif* 2006, experimental trial was conducted under sick plot field conditions against *A. flavus* to confirm the resistance of genotypes screened during summer, in addition to some new advanced breeding lines of NRCG. The soil was inoculated thrice with the most virulent isolate of *A. flavus*, AF 111 at sowing, flowering and at 90 days of crop. Observations were recorded on incidence of aflaroot and pod samples were taken. They were analysed for seed infection by *A. flavus* and aflatoxin contamination levels. The population of *A. flavus* was monitored in the sick plot. The minimum and maximum population of *A. flavus* at sowing was 9.67 x 10^3 and 18.00 x 10^3, respectively. At pod development stages the minimum and maximum population of *A. flavus* were 20- 25.33 x 10^3 and 32-34.00 x 10^3 cfu/g soil, respectively. The seed infection level varied between 10-14.5 percent. The aflatoxin contamination ranged from 0.00 to 1546.09 μg kg^{-1}. Twenty genotypes *viz.* ALR 2, B 95, BAU 13, ICGS 1, K 134, NRCG CS nos.'- 36, 38, 41, 47, 69, 76, 77, 215, 272, 273, 312 and 350, RHRG 12, TAG 24 and TAG 26 showed tolerance to *A. flavus* infection and subsequent aflatoxin contamination consistently over the years (Table 1).

Studies on pre-harvest antagonists

Isolation of bio-control agents

Isolation of the bio-control agent *viz. Trichoderma* spp. was carried out on *Trichoderma* Selective Medium (Elad *et al.*, 1981) from all the soil samples collected during survey. A total of 41 isolates of *Trichoderma* spp. could be purified and maintained as single spore culture from these samples. These were lyophilised and stored for long term preservation of genetic identity of the strains.

Table 1. Promising genotypes supporting low-load of aflatoxin (screened during 2005-2006 at NRCG, Junagadh under field conditions)

Sr. No.	Genotype	Aflatoxin B_1 (μg/kg)		
		Kharif 2005	Summer 2006	*Kharif* 2006
1.	ALR 2	1.57	33.28	64.36
2.	B 95	0.00	9.05	26.25
3.	BAU 13	0.00	0.00	0.00
4.	NRCG CS 36	2.81	6.85	-
5.	NRCG CS 38	2.66	0.00	-
6.	NRCG CS 41	3.97	44.28	0.00
7.	NRCG CS 47	1.57	1.71	2.72
8.	NRCG CS 69	0.92	3.32	-
9.	NRCG CS 76	0.95	0.00	0.00
10.	NRCG CS 77	5.97	0.00	6.52
11.	NRCG CS 215	39.07	0.00	1.67
12.	NRCG CS 272	25.46	0.00	0.00
13.	NRCG CS 273	0.00	0.00	0.00
14.	NRCG CS 312	0.58	0.00	0.00
15.	NRCG CS 350	0.00	0.00	0.00
16.	ICGS 1	9.75	0.00	
17.	K 134	21.39	0.35	5.84
18.	RHRG 12	12.23	29.70	
19.	TAG 24	6.49	0.00	0.00
20.	TAG 26	0.80	0.00	0.00
21.	J 11*	1.50	8.06	100.89
22.	GG 20**	117.70	433.74	1546.09

* Resistant check; **susceptible check

In-vitro evaluation of *Trichoderma* spp. for bio-control efficacy against *A. Flavus*

Antagonistic activity of 41 new isolates of *Trichoderma* sp. was studied under *in-vitro* conditions (bangle method) against *Aspergillus flavus* for their antagonistic potential to see the feasibility of inclusion in the pre-harvest integrated aflatoxin management package. Colony diameter of *A. flavus* was recorded after 48 hrs and 72 hrs of inoculation. The other parameters *viz.*, time taken to overgrow the pathogen, sporulation and pigmentation of media after growth was considered for assessing antagonistic potential of different isolates of *Trichoderma*. Four isolates *viz.*, NRCG T12, NRCG T16, NRCG T32 and NRCG T34 were found to be highly antagonistic showing ≥45% inhibition of growth and completely overgrew the pathogen in 5 days.

Evaluation of non-toxigenic *Aspergillus flavus* against toxigenic *A. flavus* under laboratory conditions

Antagonistic activity of 206 nontoxigenic isolates of *Aspergillus flavus* was evaluated under *in-vitro* condition adopting Bangle Method of bioassay against the most toxigenic isolate, NRCG 01 111. Colony diameter of toxigenic *A. flavus* was recorded after 48 and 72 hrs of inoculation. Though the different isolates could inhibit the toxigenic *A. flavus* significantly with regard to the radial growth, no non-toxigenic isolate could overgrow the toxigenic *A. flavus*. This experiment will be repeated to confirm the results.

Morphological and molecular characterization of isolates of *Aspergillus* spp.

Morphological characterization

A total of 417 isolates of *Aspergillus* spp. (mostly *A. flavus* and *A. ochraceus*) were isolated, purified and are being maintained as single spore cultures on agar slants (Table 2). The morphological and growth characteristics of all the isolates were studied on solid medium (PDA medium). The growth habit, colour of colony and the diameter after four days were recorded for all the isolates. The isolates varied in their sclerotial size, growth rate and sporulation. After proper identification of species they were accessioned in the Repository of Isolates of *Aspergillus* at NRCG. The isolates could be categorized in the six groups based on their colony and growth characteristics (Table 3; Figure 1 to 4). Aflatoxigenicity of isolates of *Aspergillus* spp. (mostly *A. flavus*) using ammonia vapour method as well as by indirect competitive ELISA were carried out. Out of 417 isolates of aspergilli at NRCG Accession, 75 were found highly toxic, 136 moderately toxic and 206 non-toxic as identified by Ammonia Vapour method. The toxicity was further confirmed by using indirect competitive ELISA.

Table 2. Number of isolates of *Aspergillus* spp. Collected from various districts of Gujarat

Sr. No	District	Accession number		No. of isolates
		From	To	
1	Junagadh	NRCG 01 001	NRCG 01 229	229
2	Amreli	NRCG 02 001	NRCG 02 043	43
3	Bhuj	NRCG 03 001	NRCG 03 037	37
4	Anand	NRCG 04 001	NRCG 04 011	11
5	Bhavnagar	NRCG 05 001	NRCG 05 036	36
6	S.K. Nagar	NRCG 06 001	NRCG 06 021	21
7	Jamnagar	NRCG 07 001	NRCG 07 004	04
8	Surendranagar	NRCG 08 001	NRCG 08 022	22
9	Rajkot	NRCG 09 001	NRCG 09 005	05
10	Porbandar	NRCG 10 001	NRCG 10 009	09
	Total			417

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Table 3. Characteristics of different groups of isolates of *Aspergillus* spp.

Group	Reference isolate	Colony characters		Growth characteristics		Species of *Aspergillus*
		Front	Reverse	Growth habit	Sporulation	
A	NRCG 01 018	Parrot green	Light greenish yellow	Surface mycelium scanty, fast growing	Profuse	*A. flavus*
B	NRCG 03 004	White fluffy with yellow sporulation	Light lemon yellow	Fast growth with cottony white fluffy mycelium	Moderate sporulation	*A. flavus*
C	NRCG 01 027	White turning to green in circular rings	Dark brownish yellow	Fast growing forming dark greenish rings of surface mycelium	Dark greenish sporulation	*A. nidulans*
D	NRCG 01 015	Dark creamy white with yellowish brown sporulation	Creamy yellow	Moderate growth with aerial mycelium and conidiophores	Profuse sporulation on aerial erect conidiophores	*A. ochraceus*
E	NRCG 03 003	Ochraceus center with white margin	Lemon yellow	Moderate mycelium	Sporulation moderate in center	*A. terreus*
F	NRCG 02 012	Fluorescent yellow green	Light lemon yellow	Slow growing colony with fluorescent yellow sporulation	Moderate sporulation	*Aspergillus* sp.
G	NRCG 02026	Dark Olive green	Light greenish yellow	Surface mycelium scanty fast growing	Profuse	*A. flavus*

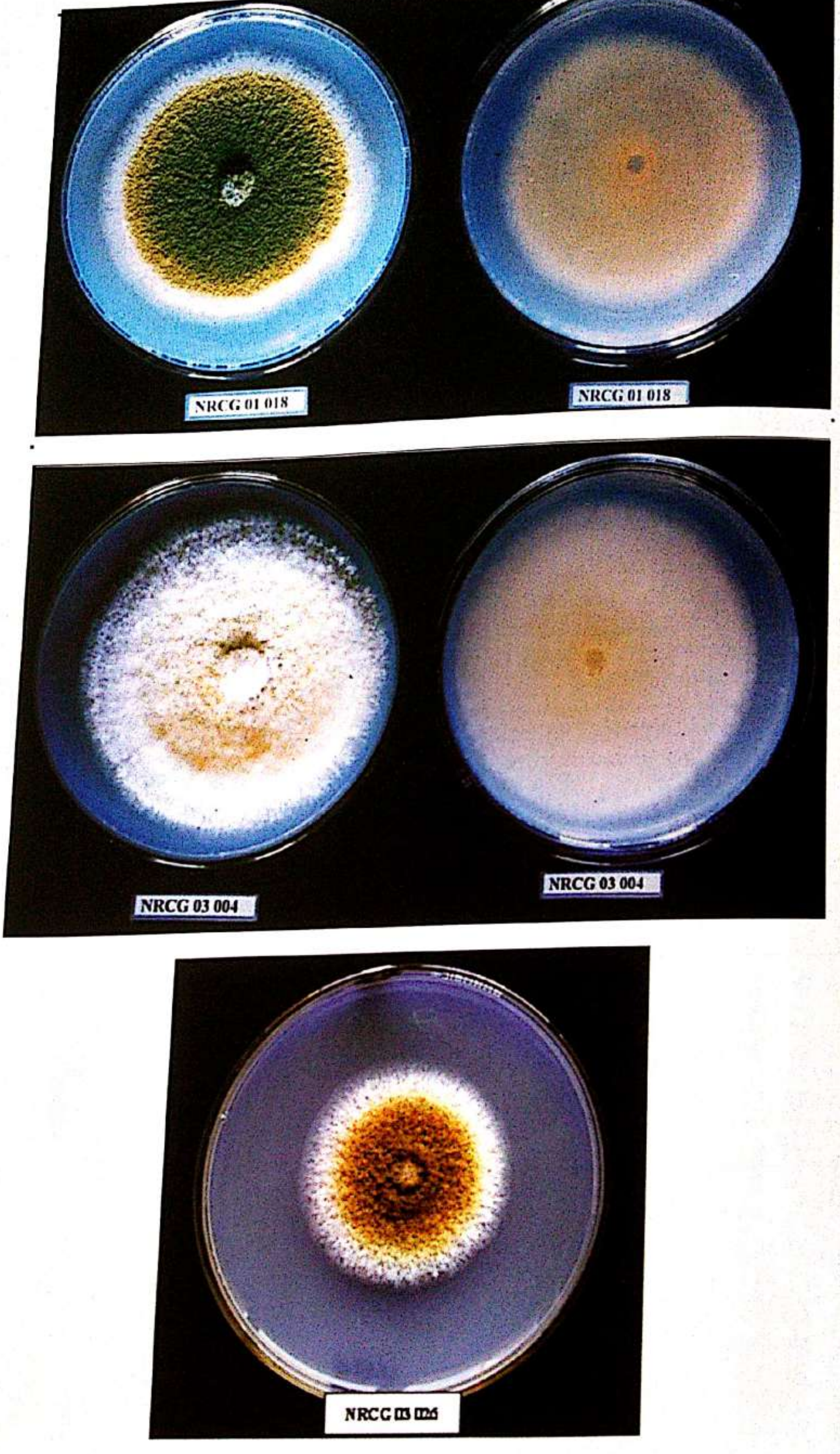

Figure 1. Colony characters of isolates of *Aspergillus flavus* (Group A, B and G) in culture

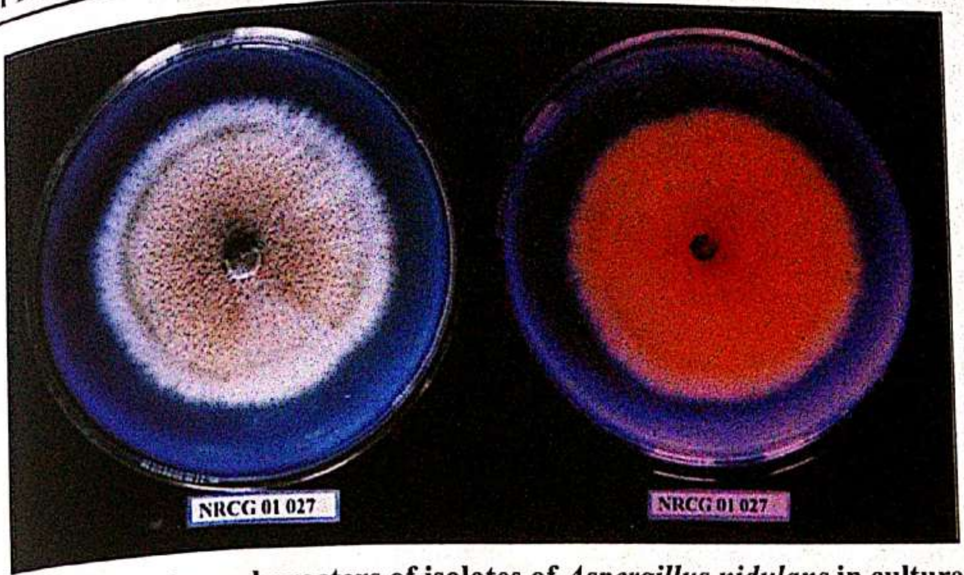

Figure 2. Colony characters of isolates of *Aspergillus nidulans* in culture

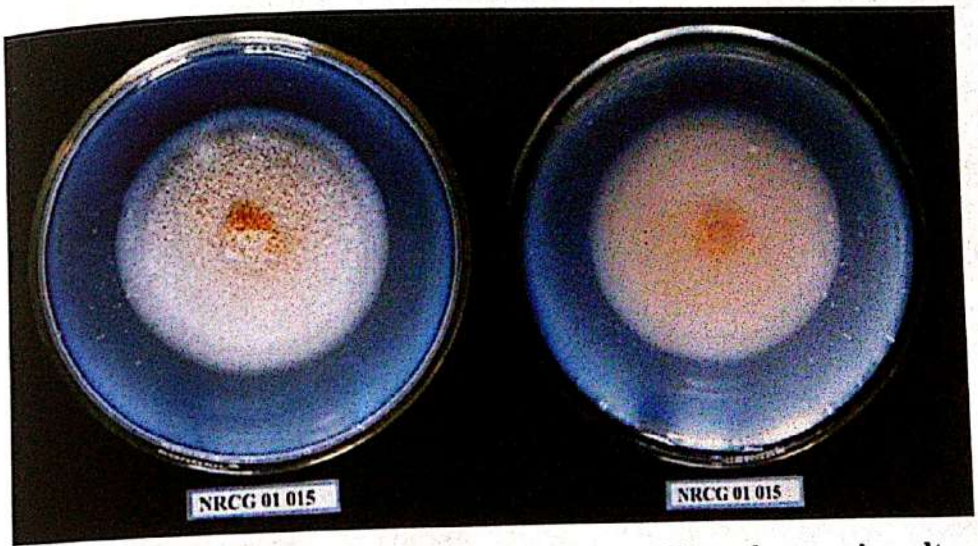

Figure 3. Colony characters of isolates of *Aspergillus ochraceus* in culture

Figure 4. Colony characters of isolates of *Aspergillus terreus* in culture

Molecular characterization of *Aspergillus* spp.

Isolation of fungal DNA and standardization of protocol for AFLP

The isolates of *Aspergillus* spp. at NRCG accession, collected from different districts of Gujarat were sub-cultured and genomic DNA was isolated, purified and estimated. Standardization of protocol for isolation of genomic DNA of *Aspergillus flavus* was done. The DNA was tested for their suitability for PCR by RAPD with random primers and was found to be amplifying. The genomic DNA was analysed for DNA polymorphism.

Molecular characterization

Using the commercial kit for microbial AFLP (Invitrogen) the protocol for AFLP of *Aspergillus flavus* was standardized and optimized. Of the ten primers recommended for fungi, ten were tried and six of them were found to amplify the genomic DNA of *A. flavus*. Some of these amplification products revealed polymorphism between the different isolates of *A. flavus*.

To further test the protocol, sixteen isolates of similar morphology (*Aspergillus flavus* Group A) but differing in toxin production capability were amplified using four primers earlier identified. Of this one primer detected polymorphism among the isolates studied. The gel was analyzed using the software Gelcompar II.

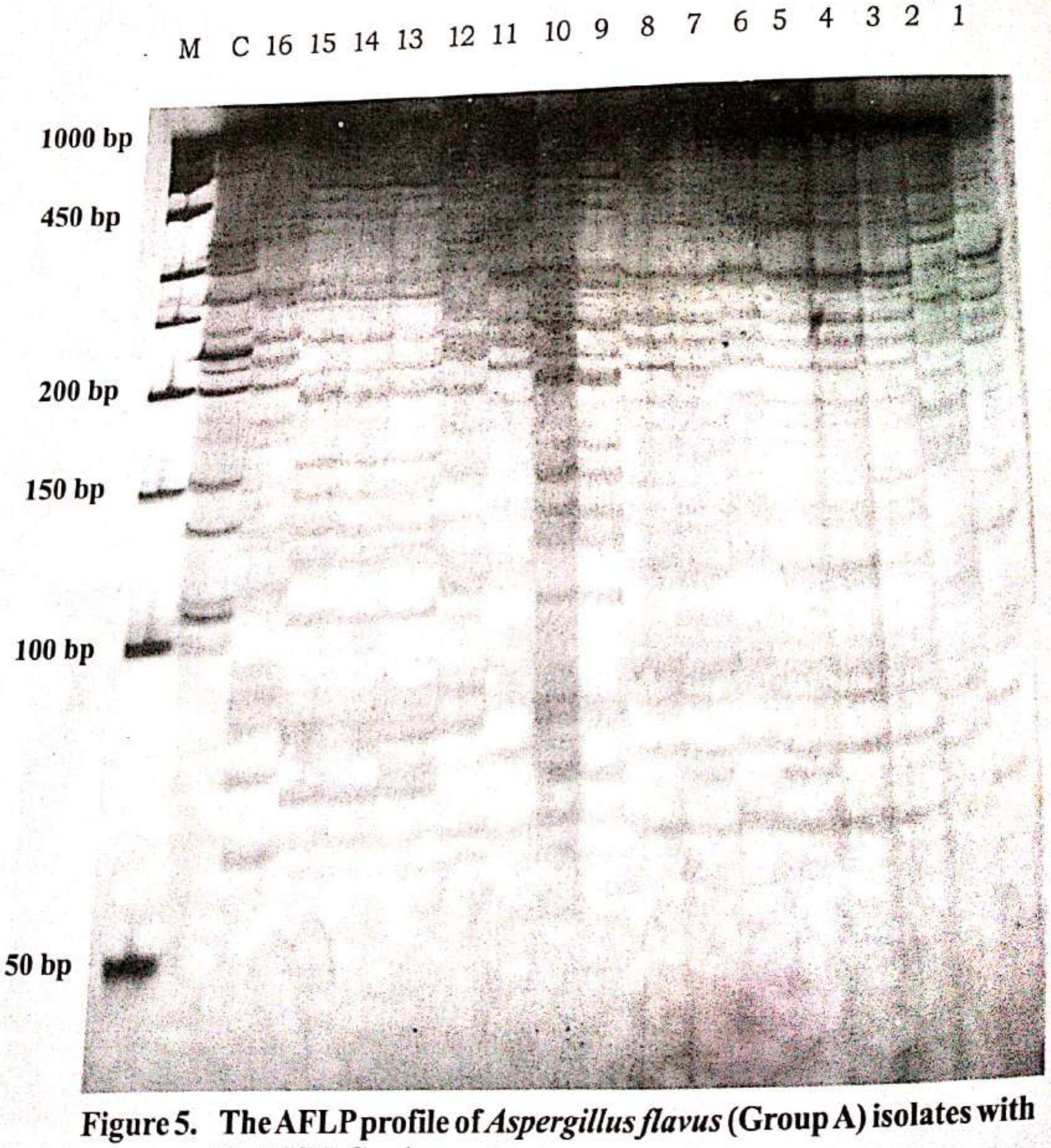

Figure 5. The AFLP profile of *Aspergillus flavus* (Group A) isolates with E-AC/M-G primer

Details of isolates, the AFLP profile of which is shown in Figure 5

Lane No.	Accession no.	Toxigenicity	District	State
1	NRCG 01016	High	Junagadh	Gujarat
2	NRCG 01009	Moderate	Junagadh	Gujarat
3	NRCG 01036	Non	Junagadh	Gujarat
4	NRCG 02002	High	Amreli	Gujarat
5	NRCG 02011	Moderate	Amreli	Gujarat
6	NRCG 02004	Non	Amreli	Gujarat
7	NRCG 03005	High	Bhuj	Gujarat
8	NRCG 03007	Moderate	Bhuj	Gujarat
9	NRCG 03024	Non	Bhuj	Gujarat
10	NRCG 04005	High	Anand	Gujarat
11	NRCG 05005	High	Bhavnagar	Gujarat
12	NRCG 05020	Moderate	Bhavnagar	Gujarat
13	NRCG 05016	Non	Bhavnagar	Gujarat
14	NRCG 06011	High	S.K. Nagar	Gujarat
15	NRCG 06009	Moderate	S.K. Nagar	Gujarat
16	NRCG 06002	Non	S.K. Nagar	Gujarat
C	*E. coli*	-	-	-
M	50 bp DNA Ladder	-	-	-

Though, this could not reveal any meaningful grouping between the isolates studied, with the use of more diverse isolates and more primers, it is expected to reveal increased diversity between the isolates already we have. This study is in progress and it is expected to produce patterns and grouping so as to determine the phylogenetic relationships of the isolates and to identify probable duplicates.

Pre-harvest management of aflatoxin contamination

Evaluation of management practices for prevention of pre-harvest aflatoxin contamination

During summer 2006, a field experiment was undertaken to evaluate an integrated management practice for prevention of pre-harvest aflatoxin contamination. The improved integrated management package consisted of following:

a. Seed treatment with Carbendazim @ 2 g/kg
b. Soil application of *Trichoderma harzianum* isolate 170 formulated in castor cake as carrier (500 kg castor cake + 2.5 kg *Trichoderma* multiplied in sorghum medium/ hectare)
c. Application of recommended dosages of fertilizers (12.5: 25: 0)
d. Application of gypsum @ 500 kg/ha at first flowering/pegging
e. Soil application of castor cake @ 500 kg/ha
f. Application of micronutrients Zn, Fe (Zn as $ZnSO_4$ @20 kg/ha and Fe as $FeSO_4$ as 0.5 % foliar spray, two sprays- 1st Spray at 35-40 DAS, 2nd at 50-55 DAS)

g. Control of pests and diseases (Monocrotophos & Carbendazim need based spray)

h. Supplementary irrigation during dry spell

i. Harvest at right maturity

The field was inoculated thrice by the most virulent strain at NRCG, AF-111 (inoculum of *A. flavus* multiplied on pearl millet grain medium and applied @ 100 kg/ha) at sowing, flowering and at 90 days of crop. The population of *A. flavus* inoculum was monitored at flowering and pod development stages. The samples from these experiments were analysed for seed infection by *A. flavus* and aflatoxin contamination levels. The improved integrated management package reduced the contamination significantly over farmers' practice.

During *kharif* 2006, this experiment was repeated. From the results it was evident that the integrated aflatoxin management package significantly reduced aflatoxin contamination.

Aspergillus flavus soil counts under Integrated Management vis-à-vis Framer's Practice

Aspergillus flavus inoculum was applied at 40 DAS and 60 DAS for the treatments *viz.*, integrated method and farmers' method. *A. flavus* soil counts were recorded before sowing, 39 DAS, 59 DAS and at harvest. *A. flavus* population was recorded before adding the inoculum in the experimental field. The data revealed that there was gradual increase up to 60 DAS, however, it was not maintained till harvest. *A. flavus* soil count was higher in farmers' methods compared to integrated method at different stages of crop growth period. There were no significant differences between genotypes for *A. flavus* soil count.

Data also revealed that the soil population of *A. flavus* was comparatively low in summer than *kharif* season. Soil population in farmer's practices was higher than the population in the integrated management practices. This may be due to application of the biocontrol agent *Trichoderma* spp. and the application of gypsum.

Effect of long-term crop rotation on aflatoxin contamination

A long-term experiment on groundnut-garlic and groundnut-onion rotation to see the effect on population of *A. flavus* and aflatoxin contamination was initiated in *kharif* 2005. The soil population count of *A. flavus* was estimated in the samples taken just after sowing and two weeks before harvest (pod development stage). The experiment was laid out in a split plot design with two cultivars, one susceptible (GG 2) and another resistant (J 11) cultivar in main plot and four rotations in subplots *viz.*, 1. Groundnut-garlic-groundnut, 2. Groundnut-onion-groundnut, 3. Groundnut-groundnut, and 4. Groundnut-fallow-groundnut. The aflatoxin content was estimated by indirect competitive ELISA.

Harvesting of *kharif* 2006 experimental trials under the project were done. The soil population of *Aspergillus flavus* was estimated in the samples, which varied between 0.0-3.4 x10^3 cfu g^{-1} soil. The aflatoxin content was estimated by indirect competitive ELISA.

Effect of application of gypsum and micronutrients on aflatoxin contamination under field condition

A field experiment was conducted in *kharif* 2005 and 2006 in RBD with three replications and eight treatments to see the effect of soil application of gypsum and micronutrients *viz.*, zinc and iron on level of aflatoxin contamination in groundnut (var. GG 2). The treatments were:

T_1: Soil application of gypsum @ 500 kg/ha at pegging

T_2: Foliar application of Fe as $FeSO_4$ (0.5%), two sprays at 35-40 DAS and 50 DAS

T_3: Soil application of Zn as Zn SO_4 @ 20 kg/ ha

T_4: T_1+T_2

T_5: T_1+T_3

T_6: T_2+T_3

T_7: $T_1+T_2+T_3$

T_8: Control

The soil samples from 0-5 cm and 10-15 cm depths from three places were taken for nutrient status analysis fore sowing to estimate the exchangeable Ca, S, Zn, and Fe in pod zone and root zone. The aflatoxin content as estimated by indirect competitive ELISA. The results showed that application of gypsum reduced the atoxin contamination level significantly; however, the Zn application enhanced the contamination level. The iar application of iron (as $FeSO_4$) though enhanced the contamination but in combination with gypsum luced the contamination level significantly.

idies on reducing post harvest aflatoxin contamination

A post-harvest experiment was conducted to see the effect of bruchid (*Caryedon serratus*) infestation and atoxin contamination in collaboration with Entomologist at the Centre. Different storage structures such as nboo basket, bamboo basket with cow dung layer, fertilizer bags, polythene lined gunny bags, cotton (cloth) gs, and ordinary gunny bags are commonly used for the short term storage of groundnut by the farmers. mples were taken from freshly harvested produce and after 3 months of storage the aflatoxin contamination el from the produce stored in the above mentioned storage structure was estimated.

ALL INDIA COORDINATED RESEARCH PROJECT ON GROUNDNUT

***Rabi*-summer 2006-07**

1. CROP IMPROVEMENT

1.1 Maintenance, evaluation and utilization of germplasm

Thirty-one wild accessions and 1623 groundnut germplasm/advanced breeding lines under three different habit groups were maintained during *rabi*-summer 2006-07 at 4 centers namely Chinthamani, Digraj, Vridhachalam and Anand. This included 48 new accessions acquired from ICRISAT by the Anand centre. In addition, 100 mini-core germplasm accessions supplied by ICRISAT were also screened at Aliyarnagar for rust and late leafspot disease of which six accessions ICG 10036, 11088, 1114, 12625, 11426, and 14705 were found to be resistant to both rust and leaf spot.

1.2 Hybridization and selection

To develop high yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses limiting groundnut yield in *rabi*-summer season, hybridization programme was undertaken during the period under report at 11 AICRP-G centers

One hundred and ninety seven new crosses involving different germplasm accessions, cultivars and advanced breeding lines were effected during *rabi*-summer season 2006-07. Of the parents involved in these crosses, substantial (24%) numbers of crosses were germplasm, followed by advanced breeding lines (33%) and the rest were released varieties (57%).

From the crosses effected earlier the total selections made was 2515 single plants and 950 line/progeny bulks. A large (97%) number of single plant selections made during the last season were in early (F_2-F_4) generations and a very few (3%) in advanced generations (>F_4). While, the reverse was true in case of progeny bulks, where the advanced generation selections constituted the bulk (79%) of the selections made and the early generation selections were low (21%).

At Vridhachalam centre, 10 interspecific crosses were made involving two diploid '**A**' genome species of the genus *Arachis; A.villosa, A. correntina*; one diploid '**B**' genome species, *A.batizocoi*; five amphidiploids and one auto tetraploid species were used in the hybridization programme. The setting (%) varied among species and amphidiploids. The range of values observed for setting % in these crosses varied from 4.1 to 17.3%.

In the interspecific crosses made earlier at this centre, at F2 generation, 151 selections could be made out of six interspecific amphidiploid derived crosses while 237 selections could also be made from thirteen interspecific crosses at F_3; in F_5 generation 109 selections were made.

1.2.1 Selection from NRCG breeding materials

During 2006, segregating and advanced generation breeding materials of 55 crosses effected at NRCG were supplied to 13 centres. These crosses were made with the objective of incorporation of earliness, water use efficiency, drought tolerance, Iron chlorosis tolerance, fresh seed dormancy, collar rot and *A.flavus* tolerance and resistance to foliar fungal diseases into broad based cultivars/genetic back grounds. From these breeding materials, 334 single plants/line bulks have been selected at 5 centres.

1.2.2 Selection from ICRISAT breeding materials

From the segregating and advanced generation breeding materials supplied by ICRISAT to various centres during 2006, for earliness, foliar disease resistance, drought tolerance, and large seeds, 114 single plants/line bulks were made in the last season at 5 centres. Of these selections 2 entries, ALG 234 and ALG 06 320 are currently under AICRP-G trials.

1.3 Varietal evaluation

A three-tier system of evaluation namely Initial Varietal Trial (IVT) Stage I, Initial Varietal Trial (IVT) Stage II) and Advanced Varietal Trial (AVT) was adopted as follows:

1.3.1 IVT Stage I

Sixteen new entries of Spanish bunch were evaluated in all the test locations across the four zones respectively. The same set of entries / trials will be repeated during ensuing *rabi*-summer season, 2007-08 to understand their performance over two years and across the locations.

1.3.2 Initial Varietal Trial (IVT - I & IVT - II, Pooled)

Sixteen entries were tested for twc years in all the four zones. Three entries, K 1319, R 2001-2, R 2001-3 in Zone III a; two entries, K 1319, VG 0107 in zone IIIb and four entries, R 2001-3, UG 3, JALW 30 and R 2001 were promoted to AVT in zone IV were promoted to AVT.

1.3.3 Advanced Varietal Trial

One entry, TCGS 156 for Zone III b which recorded 2253 kg/ha of pod and 1545 kg/ha of kernel yield which is 13% and 23% higher in terms of pod and kernel yield over TAG 24 (NC) and 28% and 34% respectively over R 8808 (ZC) has been proposed for identification.

Similarly one entry in Zone IV namely Dh 4-3 which across the three stages of testing recorded 2716 kg/ha of pod and 1906 kg/ha of kernel yield and exhibited 51% and 57% higher pod and kernel yield respectively over ICGS 44, the zonal check variety and 19% and 25% respectively over TAG 24 (NC)

2. CROP PRODUCTION

2.1 Survey of agronomic practices

The survey revealed that the majority of the farmers grew old and local cultivars. Application of herbicides, micronutrient and bio-fertilizer are not in practice, though use of gypsum is increasing. Use of lower seed rate than the recommended ones reduced plant density in many of the centres. Intercropping of groundnut with sugarcane at Vriddhachalam and cultivation of groundnut after sugar cane at Junagadh was also observed.

2.2 Water and nutrient management in polythene-mulch

At Digraj, the pod yield, haulm yield and kernel yield increased significantly under poly mulch on paired row with irrigation at 0.6 IW/CPE and RDF+*Rhizobium*+PSB followed by mulch on flat bed, irrigation at 0.8 IW/CPE & RDF, respectively.

2.3 Effect of bio-fertilizers on productivity of groundnut

At Chiplima, the pod and kernel yield (kg/ha) was highest and significant with the application of IGR 6+Recommended doses of P and K followed by Recommended doses of P and K over control.

At Jagtial, the maximum net return and B:C ratio was recorded with the application of *Rhizobium*-4+ Recommended doses of P and K. Pod and haulm yield (kg/ha) also increased due to the treatment with IGR 6 followed by NRCG 9, along with the application of Recommended doses of P and K over control and RDF alone. B:C ratio was also high with IGR 6 treatment followed by NRCG 9.

2.4 Micronutrient studies in groundnut

At Jalgaon, soil application of $FeSO_4$ @20 kg/ha gave highest dry pod yield (2092 Kg /ha) and highest net returns (Rs. 32001/ha) with highest B:C ratio.

At Jhargram the pod and haulm yield and shelling % were highest with soil application of Zn @ 20 kg/ha and seed dressing of zinc.

The net return and B/C ratio were also highest with application of $ZnSO_4$ (30 kg soil application) and Boron 2 kg/ha (seed dressing) followed by $ZnSO_4$ 20 kg+ Boron 2 kg/ha, at Vriddhachalam.

3. CROP PROTECTION

3.1 Disease situation

- The rust and late leaf spot occurred in severe form in Pollachi taluk at Aliyarnagar and Vriddhachalam towards maturity of the crop. At Jalgaon, leaf spots and rust were not observed during the season and was negligible to low at Dharwad, Junagadh, Kadiri and Raichur.
- Stem rot incidence was low to moderate at Dharwad, Junagadh and Raichur and was negligible at Jalgaon and Kadiri. At Vriddhachalam, root rot and stem rot incidence was <10.0%.
- Incidence of PBND was low at Dharwad and Junagadh. At Kadiri, percent incidence of PBND ranged from 1.5- 14.7 and that of PSND was 1.0 to 5.5 %. At Raichur, PBND incidence reached as high as 12-29% one week before harvest at RARS Farm and up to 18% in farmers' fields.
- The severity of powdery mildew was 2-60 % at various stages and at different locations at farmers' fields of Jalgaon which were sown in the month of late January and February.

Disease	Entries (germplasm)	Location
Germplasm entries		
PBND	NRCG-CS-036, CS-107, CS-185 and TGBL-5 (< 5% disease); NRCG-6696, NRCG-9238, NRCG-13117, NRCG-13129, NRCG-13078, CS-020, CS-081, CS-019, CS-127, CS-197, CS-205 and CS-222 (<10% disease).	Raichur
	AIS-2006-3 and Dh-86	Dharwad
LLS and rust	INS-I-2006-5, INS-I-2006-10, INS-I-2006-13, AIS-2006-1 and AIS 2006-11 (<5 grade)	Aliyarnagar
Stem rot	AIS-2006-5 (<5%)	Dharwad
IVT, AVT stage I and AVT Stage II entries		
PBND	LSVT-5 and LSVT-6; IVT-II-2006-7, IVT-II-2006-13, IVT-II-2006-14, IVT-II-2006-16 (<5.0%)	Dharwad
	INS-I-2006-11, LSVT-I-2005-3 (zero incidence)	Kadiri
	IVT-I-2006-3, IVT-I-2006-5, IVT-I-2006-12 and AIS-2006-5 (<5.0 %)	Raichur
PSND	INS-I-2006 - 5, 6, 11, 15 and AIS-2006-3; INS-I-2006 -1, 7 and LSVT-I-2005-3 and K 1340	Kadiri

LLS & Rust	INS-1-2006-1, INS-1-2006-2, INS-1-2006-3, INS-1-2006-5, INS-1-2006-9, INS-1-2006-II, INS-1-2006-12 and INS-I-2006-17; IVK-1-2006-2, IVK-1-2006-3, IVK-1-2006-4, IVK-1-2006-12 and IVK-1-2006-14; AIS-2006-3, AIS-2006-4, AIS-200611 and AIS 2006-12 ; LSVT -1-2006-6 and LSVT-1-2006-7; DRVT-1-2006-3, DRVT-1-2006-4 and DRVT-1-2006-5	Vriddhachalam
Stem rot	LSVT-6, LSVT-8, LSVT-12, LSVT-11 (Mutant-III); IVT-II-2006-6, IVT-II-2006-7, IVT-II-2006-9, IVT-II-2006-10, IVT-II-2006-11, IVT-II-2006-13, IVT-II-2006-16, IVT-II-2006-18, IVT-II-2006-19 and IVT-II-2006-20 (< 5.0%)	Dharwad
	INS-II-2005-13 and 14 and NRCG-(R)-II-2005-03 & 07 (<15% incidence)	Jalgaon

3.3 Disease Management

- Soil drenching with *T. viride* @ 2.5 kg/ha at 30 DAS was found significantly superior in controlling stem rot of groundnut at Junagadh and Raichur centres, while at Vriddhachalam, the soil application of *T. viride* @ 2.5 kg/ha along with 500 kg of castor cake recorded less incidence of stem rot (8.9%), followed by soil drenching with *T. viride* @ 2.5 kg/ha (9.8%).
- At Raichur, seed treatment with Mancozeb @ 4 g/kg seed recorded least root rot incidence (2.34%) followed by seed treatment with *P. fluorescens* @10 g/kg + soil application of *P. fluorescens* @ 2.5 kg/ha (2.75 %) while at Vriddhachalam, the least incidence (4.5%) was recorded in the seed treatment with *Pseudomonas fluorescens* + soil application of *P. fluorescens* followed by seed treatment of *Trichoderma viride* (4.8%) as against 17.8% in control. At Kadiri, seed treatment with *Trichoderma* sp @ 4 g/kg + soil application of *Trichoderma* sp @ 2.5 kg/ ha at 30 DAS was promising in reducing dry root rot disease.
- Two sprays of calaxin @ 0.1% and contaf @ 0.1% were found most effective in controlling powdery mildew (*Odium arachidis)* on groundnut recording 100% disease control at Jalgaon.

3.4 Insect pests

3.4.1 Insect pest situation

- At Dharwad, in Shiggoan taluka of Haveri district, *Spilarctia obliqua* (*Spilosoma obliqua* Walker) out break (50-60 % damage) was noticed in groundnut.
- At Jalgaon, the incidence of thrips was in the range of 2-40 % in different farmers' fields.
- At Vriddhachalam, leaf miner incidence varied from 11.0-24.1% during vegetative phase, 9.6-23.4% during pod formation stage and 8.4-20.6% during maturity phase.
- At Jagtial, the per cent leaf damage due to thrips (5-40), jassids (20-80), aphids (1-20) and leaf miner (1-30) was high at vegetative stage and *Spodoptera* defoliation (5-45) was high at pod formation stage. At Kottagattu, Shankarapatnam mandal very severe incidence (2-4 larvae/plant) and per cent defoliation (35-40) due to Bihar hairy caterpillar was observed at Vempet, Korutla, Karimnagar district during pod formation stage.

At Raichur, the highest number of leaf miner larvae per plant (17.8) was noticed during vegetative phase at Chinchodi village of Deodurga taluka under late sown condition.

3.4.2 Host-resistance against insect-pests

Insect pest	Genotypes	Centre
Thrips, Jassids and *Spodoptera litura*	INS 2006-05	Jagtial
Thrips and Jassids	AIS 2006-09	Jagtial
Leaf miner	INS 2006-02 and AIS 2006-01	Jagtial
Spodoptera litura	AIS 2006-05	Jagtial
Thrips	ISK-I-2006-10 & 14, INS-II-2005-9, NRCG-(R)-2005-6 and ICGV-91192	Jagtial
Thrips	AIS-I-2006-3, 9 and 12, INS-I-2006-7, 8, 10, INS-I-2006-8, INS-I-2005-2, 4, 7, 18 and 19	Junagadh
Jassids	AIS-I-2006-2, 3 and 11, INS-I-2006-4 and 8, and INS-I-2005-16	Junagadh
Helicoverpa armigera	AIS -I-2006-1, INS-I-2006-13, 15 and 17 and INS-I-2005-6, 14 and 16	Junagadh
Thrips, Jassids and *Spodoptera litura*	INS 2006-05	Jagtial
Thrips and Jassids	AIS 2006-09	Jagtial
Leaf miner	INS 2006-02 and AIS 2006-01	Jagtial
Spodoptera litura	AIS 2006-05	Jagtial
Thrips	ISK-I-2006-10 & 14, INS-II-2005-9, NRCG-(R)-2005-6 and ICGV-91192	Jalgaon
Thrips	AIS-I-2006-3, 9 and 12, INS-I-2006-7, 8, 10, INS-I-2006-8, INS-I-2005-2, 4, 7, 18 and 19	Junagadh
Jassids	AIS-I-2006-2, 3 and 11, INS-I-2006-4 and 8, and INS-I-2005-16	Junagadh
Helicoverpa armigera	AIS -I-2006-1, INS-I-2006-13, 15 and 17 and INS-I-2005-6, 14 and 16	Junagadh
Thrips	INS-I-2006-5 and 7, INS-I-2005-2 and AIS-2006-1 and 12	Kadiri
Leaf miner	ICG-5240	Raichur
Leaf miner	INS-I-2006-5,16, AIS 2006-1-4 and 9, ISK-I-2006-4,6 and IVK-I-2006-6	Vriddhachalam
Spodoptera litura	AIS-2006-4 and 9	Vriddhachalam

3.4.3 Monitoring of *Spodoptera* and leaf miner male moths using pheromone traps

At Jagtial, the highest number of *Spodoptera* moths catch was recorded on 47th standard week 422 moths/2 traps followed by 42nd Std week (170 moths) and 46th Std week (121 moths).

At Jalgaon, the highest number of *Spodoptera* moths catch was recorded during 18th met. week (94.5 moths/trap).

At Vriddhachalam, two peak activities of *S. litura* was noticed during 30.01.07 to 09.02.07 (5-19 adults/trap) and 15.03.07 to 23.03.07 (9-78 adults/trap).

3.4.3 Monitoring of *Spodoptera* and leaf miner male moths using pheromone traps

At Jagtial, the highest number of *Spodoptera* moths catch was recorded on 47th standard week 422 moths / 2 traps followed by 42nd Std week (170 moths) and 46th Std week (121 moths).

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At Vriddhachalam, two peak activities of *S. litura* was noticed during 30.01.07 to 09.02.07 (5-19 adults/trap) and 15.03.07 to 23.03.07 (9-78 adults/trap).

3.4.4 Integrated management of defoliators

At Vriddhachalam, IPM module showed significantly lower incidence of *S. litura* (16.1-16.9%) and leaf miner (19.7-23%) as compared to control with 18.1-28.4% and 19.8-26.3% incidence of *S. litura* and leaf miner respectively.

3.4.5 Biological control of *S. litura* with *Nomuraea rileyi*

At Vriddhachalam, spraying of *N. rileyi* @ 2 g/lit and NSKE 5% recorded a yield of 1290 kg/ha with a CBR of 2. The incidence of *S. litura* also was reduced to 14.2% as compared to control (31.9%).

3.4.6 Isolation and identification of plant parasitic nematodes in groundnut

At Kadiri, out of 120 soil and root samples collected for isolating plant parasitic nematodes results revealed that *Xiphinema* spp., *Rotylenchulus reniformis* and *Helicotylenchus* spp. populations were highest in Kadiri Mandal and Ponnuru mandal of Guntur. Whereas, in Anantapur and Kadapa districts, *Helicotylenchus* spp was more prevalent in groundnut fields followed by *R. reniformis* and *Xiphinema* spp.

4. Front Line Demonstrations

A total of 280 Front Line Demonstrations (FLDs) were allotted on six different components during *rabi*-summer 2006 to 19 centers in the major groundnut growing states such as Andhra Pradesh, Gujarat, Maharashtra, Orissa, Karnataka, Rajasthan, Tamil Nadu, West Bengal and Mizoram.

The results of 109 FLDs on improved varieties from 12 centres indicated that the highest average pod yield of 3126 kg/ha was realized at Tirupathi centre compared to local variety (2633 kg/ha) and lowest yield of 1475 kg/ha was realized at Raichur centre with R-2001-03 variety compared to 872 kg/ha with local variety. On an average there was 29% increase in pod yield with improved variety compared to local variety.

The results of 22 FLDs conducted at five centres on integrated nutrient management indicated that on an average improved practices recorded 44 % increase in pod yield over farmers practice. At chintamani application of micronutrients increased pod yield by 19.4%. The application of PGPR at Jhargram centre increased the pod yield by 14.1% over farmers practice.

Five FLDs on Polythene Mulch Technology (PMG) at Akola centre increased the pod yield by 52.6 % over farmers practice. FLDs on integrated weed management (IWM) at Vriddachalam increased the pod yield by 12.2 % over farmers practice.

Five FLDs on integrated pest management conducted at Jagtial showed that there was an increase in pod yield by 15.7% over farmer's practice of pest management.

***Kharif* 2006**

1. CROP IMPROVEMENT

1.1 Maintenance, evaluation and utilization of germplasm

Forty-one wild accessions and 4790 groundnut germplasm/advanced breeding lines under four different habit groups were maintained during *kharif* 2006 at nine centers located in Gujarat, Maharashtra, Karnataka, Andhra Pradesh, Rajasthan and Tamil Nadu. The germplasm maintained in these centres included 1256 new accessions acquired from NRCG, ICRISAT and BARC

1.2 Hybridization and selection

To develop high yielding groundnut cultivars possessing resistance to various biotic and abiotic stresses limiting groundnut yield in *kharif* season, hybridization programme was undertaken during the period under report at 13 AICRP-G centers. Altogether, one hundred and fifty new crosses involving different cultivars/advanced breeding lines, germplasm accessions were effected during *kharif* season of 2006

From the crosses made earlier progenies of 828 crosses were advanced to their respective next filial generation from which, a total number of 11,185 selections were made for high yield, oil content, earliness, fresh seed dormancy, resistance to drought, diseases (rust, ELS, LLS, PBND, stem rot, collar rot), insect pests (*Spodoptera*, leaf miner, thrips) and other attributes at different generations and advanced to their respective filial generations at 16 AICRP-G centres. The selections comprised of large number (7592) of single plants and 2804 line/progeny bulks.

Eleven inter specific back cross derivatives were evaluated to assess their disease reaction (Foliar fungal) and yield performance at Vridhachalam centre. In various varietal station (Advance trials) trials, three entries, VG 0433 and VG 0436 (AVT I), and VG 9816 (AVT II) were found promising. In preliminary yield trials (Initial Varietal Trial I & II), three VG 0507 and VG 0512 (IVT I) and VG 0430 (IVT II) were found promising over their best check, VRI 2.

From the segregating materials of 49 crosses supplied to 13 AICRP-G centres, 580 location and objective specific selections were made. Similarly, 793 selections from 62 crosses supplied by ICRISAT were also made at various AICRP-G centres.

1.3 Varietal evaluation

A three-tier system of evaluation namely Initial Varietal Trial (IVT-Stage I), Initial Varietal Trial (IVT Stage II) and Advanced Varietal Trial (AVT) was adopted as follows:

1.3.1 IVT Stage I

Twenty six new entries of Spanish, twenty three entries of Virginia and ten large seeded entries were evaluated in all the test locations across the five and four zones, respectively. The same set of entries / trials will be repeated during ensuing *Kharif* season, 2006 to understand their performance over years and across the locations.

1.3.2 Initial Varietal Trial (IVT I & II, Pooled)

Twenty four and fifteen entries were tested for two years in all the five and four zones respectively among Spanish and Virginia entries with suitable national and zonal checks, respectively. The following entries were promoted in their respective zone based on their superior yield performances over the best check variety concerned

Entry	Zone in which promoted	State
A. Spanish		
CSMG 2014, UG 33 , J 63, R 2001-2	Zone IV	Orissa, West Bengal, Manipur, Jhakhand
VG 9816	Zone V	Tamil Nadu, Andhra Pradesh, Karnataka, Southern Maharashtra
B. Virginia		
CSMG 2014, UG 33 and J 63	Zone IV	Orissa, West Bengal, Manipur, Jhakhand
C. Large-seeded types		
K 1341	All India	-

1.3.3 Advanced Varietal Trial

Spanish: Three entries, JL 501, R 2001-2 and R 2001-3 were tested in zone II to assess their performance across five locations. The entry JL 501 was found to be superior in zone II across different stages of testing over three years and it is proposed for identification in zone II.

Virginia: Three entries were tested under this trial at two zones and all the three entries, PBS 24030 (Zone I), ICGV 00348 and AK 267 (Zone V), were found to be superior over their respective best check varieties in respect of pod and kernel yield and hence are proposed for identification.

Entry	Identified for	State	Yield (kg/ha)	Salient feature
Spanish				
JL 501	Zone II	Gujarat, southern Rajasthan	1661 (P) 1105 (K)	Small seeded, Early (102 d)
Virginia				
PBS 24030	Zone I	Rajasthan, UttarPradesh, Punjab	2909 (P) 1999(K)	Large seed (60 g/100 kernel); high oil (50%) and shelling (68%)
ICGV 00348	Zone V	Tamil Nadu, Andhra Pradesh, Karnataka, Southern Maharashtra	2013 (P) 1310 (K)	Resistant to rust, LLS and tolerant to stem rot
AK 267	Zone V	Tamil Nadu, Andhra Pradesh, Karnataka, Southern Maharashtra	1754 (P) 1163 (K)	Resistant to rust, LLS and tolerant to stem rot

1.3.4 Large-seeded varietal trial

Under Large-seeded Varietal Trial (LSVT-I) currently nine entries are under evaluation while in LSVT-I&II, one entry, K 1341 was promoted to AVT as it was found superior than the best check for pod as well as kernel yield in all the three years of testing with high shelling (69%) and low oil (46%).

1.3.5 Initial drought resistant varietal trial

Eighteen entries which were bred and evaluated at various AICRP-G centres were assembled and evaluated along with suitable Zonal/local but popular drought tolerant groundnut varieties at eight target environments under early (Vridhachalam, Anantapur, Tirupati) , mid (Chinthamani, Raichur and Jalgaon) and end (JAU, Junagadh, Durgapura) of season drought situations.

Based on two years performance eight entries were promoted to Advanced Drought Resistance Varietal Trial (ADRVT) under the three defined moisture stress environments. These trials will be continued under rainfed conditions for three more years to assess the merit of the entries.

1.4 Breeder seed production

During the period under report, an indent of 3855 q of groundnut breeder seed for 46 groundnut varieties was received from DAC. Based on the availability of nucleus seed & breeder seed stage I, a production target was allotted to 16 participating centres. During *kharif* 2005, 1861.15 q could be produced. To mitigate the short fall a compensatory programme was undertaken during *rabi*-summer 2005-06 and the anticipated production is about 5648.35 q leaving a surplus production of 1793.4 q.

2. CROP PRODUCTION

2.1 Survey of agronomic practices in the farmer's field

The survey indicated that the majority of the farmers grew age old and local cultivars. Except Gujarat, farmers adopted low seed rate than recommended. Application of herbicide, micronutrient and bio fertilizer were not very common. Use of gypsum is on the increase.

2.2 Effect of plant density and fertilizer along with in-situ moisture conservation on productivity of groundnut

Adoption of *in-situ* moisture conservation increased pod yield by 11.6-20.4 % over the control at Aliyarnagar, Durgapura and Jhargram. The results indicated that there is a possibility of reducing plant population and fertilizer dose (up to 25%) when *in-situ* moisture conservation technique is adopted.

2.3 Effect of supplementary irrigation on productivity of Pigeon pea/castor intercrop with groundnut

In groundnut + pigeon pea intercropping, applying irrigation to pigeon pea at 0.5 IW/CPE at Aliyarnagar and 0.75 IW/CPE at Digraj and Junagadh gave maximum net returns and BCR of the system. In groundnut + castor intercropping, applying irrigation to castor at 0.75 IW/CPE at Junagadh gave maximum net returns and BCR of the system

2.4 Micronutrient management in groundnut

Application of Zinc sulphate @ 30 kg/ha as soil application increased pod yield significantly at Chinthamani and Hanumangarh, 20 kg/ha as soil application at Digraj. In Chiplima 0.5 kg/ha sodium molybdate as seed dressing and Boric acid @ 12 kg/ha as soil application at Mainpuri increased pod yield significantly over the control.

2.5 Intercropping of groundnut with cotton

The one year result on intercropping groundnut with cotton at Dharwad, Hanumangarh, Digraj, Junagadh, Jalgaon and Tindivanam indicated that cotton yield was not reduced much under intercropping system. The total return of the system was significantly higher than that under either of sole cropping.

2.6 Effect of consortia of beneficial microorganisms on the growth and yield of Groundnut

The one year result indicated that application of consortia of beneficial microorganisms increased pod yield by 13-15% over the control. The results also indicated that 25% of the fertilizer dose can be replaced by the use of consortia in rainfed groundnut.

3. CROP PROTECTION

3.1 Disease situation

Among foliar fungal diseases, late leaf spot were found to be severe at Aliyarnagar (Pollachi tract), Dharwad Jalgaon, Raichur; moderate at Kadiri, Vriddhachalam and Ludhiana and low at Junagadh and Latur. Among the seed and seedling diseases, the collar rot and stem rot incidence were low (1-13%) at most of the centres.

At Raichur, PBND incidence ranged from 22-46% and 2-20% in farmers fields. At Vriddhachalam, and Ludhiana the incidence of PBND was low and was not noticed at Junagadh. At Hanumangadh, the incidence of PBND varied from 1-13%.

3.2 Disease resistance

Disease	Resistant/tolerant entries	Hot spot location
ELS	ISK-I-2006-13 and ISK-I-2006-18; IVK-I-2006-14; ISK-II-(R) 2006-1	Hanumangadh
	ISK-I-2006-8	
	ISK-I-06-8 and LSVT-I-06-3	Latur
LLS	ISK-I-2006-8; AVK 2006-2, 3 and 5; LSVT-I-2006-3 and LSVT-II (R)-2006-2	Aliyarnagar Dharwad
	ISK-II-05-6, ISK-II-05-7, ISK-II-05-17 and ISK- II-05-19; ISK-II(R)-06-1, ISK-II(R)-06-2; IVK-II-05-10, IVK-II-05-12, IVK-II-05-13; IVK-II (R)-06-1, IVK-II(R)-06-4 and IVK-II(R)-06-6	Jalgaon
	ASK-I-2006-1, ASK-I-2006-3 and ASK-I-2006-5; DRVT-I-2006-7, AVK-2006-5, ISK-I-2005-23, IVK-I-2005-2	Kadiri
	DRVT-I- 2006-7, LSVT-I-2006-2, 11199, 11275, 10784, 11236, 11255, 13450, 13526, 11258 and 11195; NRCG CS lines CS-019, -060, -070, -072, -073, -077, -078, -085, -086, -107, -124, -186, -192, -196, -207, -210, -222, -257, R-2001-3 and GPBD-4; NRCG-PBS-12163, -12167, -13018, -15011 and -30046	Raichur
	ISK 2006-1, 2, 3, 4, 5, 6, 8, 9, 11 and 12; IVK II 2006-4 and 6; AVK 2006-1, 2, 3, 4, 5 and 6; DRVT 2006-7; and LSVT 2006-3, 4 and 5	Vriddhachalam
Rust	ISK-I-06-6, AVK-06-2, AVK-06-3; NRCG-06 -1 and NRCG-06-2	Aliyarnagar
	ISK-1-2006-5 and 15, AVK 2006-2, 5 and 8; DRVT-I-2006-3, LSVT-I-2006-3, 6 and 7; LSVT-II-(R)-2006-1, 2 and 3	Dharwad
	LSVT1-06-3, ISK-II-05-17	Junagadh
	ASK-I-2006-1, ASK-I-2006-3 and ASK-I-2006-5; IVK-I-2006-6, LSVT-II(R)-2006-1, ADRVT-2006-1, AVK-2006-7 ISK-I-2005-23, IVK-I-2005-2,IVK-I-2005-5, IVK-I-2005-10, LSVT-I-2005-4 and LSVT-I-2005-7	Kadiri
	ISK-1-2006-1, 2, 3, 4,5,6,7, 10 and 11; IVK II 2006-4; AVK 2006-1,4 and 5; DRVT 2006-5,6 and 7 and LSVT 2006-5	Vriddhachalam
	ISK-I-2006-6	Latur
	IVK-I-2006-4, IVK-I-2006-6 and IVK II- (R)-2006-4	Dharwad
LLS + Rust	IVK-1-2006-2, IVK-1-2006-4 and ISK 2006-4	Vriddhachalam
	IVK-I-2006-4 and IVK-I-2006-6	Dharwad
Stem Rot	CS-015, -121, -127, -180, -185, -192, -195 and -196	Raichur
PBND	ISK-2006-12; germplasm lines 11181 and 10784; NRCG CS-085, R-2001-1 and R-2001-3; 13006, 13040, 13069 and 4212	Raichur
	ISK-I-2006-5, 11, 12 and 14; DRVT-2006-3; LSVT I-2006-7 and LSVT-II-2006-1 and AVK-2006-2, 3	Latur
PSND	ISK-I-2006-15, ISK-II(R)-2006-3, ISK-II(R)-2006-4, ISK-I-2006-18 and ISK-II(R)-2006-2, LSVT-I-2006-7, AVK-2006-8, ISK-I-2005-23, ISK-I-2005-17 and ISK-I-2005-19, IVK-I-2005-10 and IVK-I-2005-4	Kadiri

3.3 Disease Management

3.3.1 Biological control of major diseases of groundnut using *Pseudomonas fluorescens*

At Jalgaon and Junagadh, *Pseudomonas fluorescens* significantly reduced stem rot giving better pod yield. At Vriddhachalam, seed treatment with *Pseudomonas fluorescence* (Pf 1) + soil application of *Trichoderma viride* 2.5 kg/ha at 30 and 40 DAS recorded the least incidence of root rot and stem rot.

3.3.2 Demonstration trial on farm yard manure based *Trichoderma* sp. (local culture) against soil borne diseases at research station

At Dharwad, minimum incidence of stem rot was recorded in seed treatment with Captan followed by soil application of FYM based *Trichoderma*. At Jalgaon, minimum incidence of collar rot and stem rot was found in application of FYM based *Trichoderma*. At Junagadh, seed treatment with Mancozeb followed by soil application of FYM based *Trichoderma*. At Junagadh, seed treatment with Mancozeb followed by soil application of FYM based *Trichoderma* was comparatively better in reducing stem rot as compared to FYM based treatment with *Trichoderma* was comparatively better in reducing stem rot as compared to FYM based *Trichoderma*, however, the pod and fodder yields were highest in FYM based *Trichoderma*.

At Raichur, least incidence of collar rot, stem rot, root rot and pod rot was recorded in soil application of FYM enriched formulation @ 25 kg/ha. At Vriddhachalam, basal application of FYM enriched formulation of *Trichoderma* sp. recorded the least incidence of root rot and stem rot. At Hanumangadh, least incidence of collar rot was observed through soil application of FYM enriched formulation @ 10 kg/ha.

3.4. Evaluation of IPM modules on farmers' fields

At Dharwad, seed treatment with *Trichoderma* @ 4 g/kg seed + intercropping of Navane (*Setaria italica*) one row for every eight rows of groundnut + sowing of sunflower around the field + furrow application of neem cake @ 200 kg/ha was superior in controlling LLS and rust.

At Kadiri, seed treatment with *Trichoderma viride* @ 4g/kg seed recorded lowest collar rot and dry root rot. At 90 DAS the LLS recorded in IPM package was lowest (4.0) as against 6.0 grade in Farmers practice.

At Raichur, seed treatment with *Trichoderma* @ 4 g/kg seed + border crop of sorghum (4 rows) + spraying of Hexaconazole (0.1%) at 35, 50 and 65 DAS was found superior in controlling PBND, LLS and rust diseases. At Vriddhachalam, the IPM module recorded lesser incidence of root rot, stem rot, LLS and rust. CBR was higher in IPM module (1:2.5) as compared to Farmers' Practice (1:1.8). At Latur, IPM module recorded lesser incidence of stem rot, LLS and rust and recorded maximum pod yield.

3.5 Insect pests

3.5.1 Insect pest situation

At Dharwad *Spodoptera* incidence ranged from 20 - 25% during vegetative stage, 35 to 40% during pod formation stage and 30-40% during maturity stage. At Jalgaon larval infestation of *Spodoptera* was maximum (20-30 %) during pod development.

At Jagtial per cent leaf damage due to thrips was maximum (10-60%) during vegetative stage. Leaf damage due to Jassids ranged from 30-80%, *Spodoptera litura* (15-45%). At Kadiri red hairy caterpillar incidence was very high (65-78%) in Chekrayapeta mandal of Cuddapah district during pod development.

At Vriddhachalam incidence of leaf miner was moderate during vegetative phase (17.5-38.7%) and maturity phase (18.0-31.2%) and it was high during pod formation stage (39.1-62.1%).

3.5.2 Host resistance against insect pests

Insect pest	Genotypes	Centre
Spodoptera litura	ISK-I-2006-4,5,6,14 & 15, ISK-2005, 17,19 and 23	Dharwad
Thrips, jassids and *Spodoptera litura*	ISK-I-2006-6 and IVK-2005-2 AVK-2006-2	Jagtial
Thrips	ISK-2005-17, IVK-I-2006-7 and 13	Jagtial
Leaf hopper	ISK-2005-3 and 11, IVI-I-2006-13	Jagtial
Spodoptera litura	ISK-2005-14 and 16 IVI-I-2006-19	Jagtial
Spodoptera litura	ISK-I-2006-14 ISK-II-2005-12, IVK-I-2006-2 and IVK-I-2006-11LSVT-II-(R)-2006-1 ADRVT-2006-4, ICGS-76, HPS-9703, DVB-205, JL-598 JL-643	Jalgaon
Thrips	ISK-I-2006-18, -4, and ISK-I-2006-8, ISK-II-2005-17, -11, -13, -14 and -18	Junagadh
Thrips	ISK-I-2006-5, 15 &18 ISK-II(R)-2006-2, IVK-I-2006-2&10 IVK-II-(R)-2006-6 LSVT-I-2006-3&4 AVK-2006-2 & 6 ISK-I-2005-2, 4,7,12,13,14,15 & 23 IVK-I-2005-5&14 LSVT-I-2005-1&7	Kadiri
Leaf miner	ISK-I-2006-4 & 5, DVRT-I-2006-3, LSVT-I-2006-3 and AVK-2006-6	Latur
leaf hopper	AVK-2006-05 - 01-05-17 and ISK- 01-05-13 AVK-2006-05	Tirupati
Leaf miner	ISK-I-2006-4, 6 and IVK II R 2006-4, INSI 2005-1,2,9 and 10	Vriddhachalam

3.5.3 Demonstrations of IPM modules on the field of research farm

At Jalgaon IPM package consisting of (i) Basal application of castor cake @ 500 kg/ha. (ii) Seed treatment with *Trichoderma* @ 5g/kg seed (iii) Groundnut +Soybean (4:1) intercrop (iv) Border crop of castor (v) Spray of NSE@ 5% (vi) If necessary spray of recommended chemical (vii) Bird perches: 50 No./ha. and (viii) Pheromone trap 10 No./ha recorded higher BCR (1:1.32) compared to the normal cultivation practices.

At Vriddhachalam IPM package consisting of (i) Basal application of neem cake @ 500 kg/ha (ii) Seed treatment with *T. viride* @ 4 g/kg seed (iii) Intercropping castor (4:1), (iv) Pheromone traps 10/ha, (v) Bird perches 50/ha, (vi) Neem oil 2% (15 DAS), (vii) SLNPV at 20 DAS (viii) NSKE 5% (45 DAS) has recorded an overall increase of 14.4% in yield over farmers practice consisting of three rounds of chemical spray during 30, 50 and 70 DAS in fields. The average yield of IPM field was 1893 kg/ha and it was 1656 kg/ha in fields with farmers' practice. Leaf miner incidence was also higher in the farmers' practice field, 57.8% and 62.4%, during vegetative and pod formation stage and it was lower in IPM field, 37.6% and 37.4 %, during the respective stages.

3.5.4 Monitoring of *Spodoptera* and leaf miner male moths using pheromone traps

Spodoptera litura

Highest *Spodoptera* male moth activity was noticed during 38th Standard week (884 moths/week) at Dharwad, during 39th standard week (1065 moths/2 traps) at Jagtial, during 34th std. week (218.5/trap/week) at Junagadh. At Kadiri during 36-38th and 40-42nd week, at Latur maximum on 31st standard week (350/trap/week) and at Raichur during 1st week of June to 4th week of December.

Leaf miner

At Vriddhachalam leaf miner showed four peak activity period during 26th to 27th, 31st to 32nd, 36th to 37th and 39th to 40th Standard weeks with an adult moth attraction of 49.5-148.5, 90.0-108, 54.0-270 and 172-179 adults/traps respectively.

3.5.5 Population dynamics of thrips and PSND/PBND incidence on groundnut

At Jagtial incidence of thrips was high (30/10) on 20.07.2006 and 23/10 for thrips 10 terminal buds on 11.11.2006. The percent leaf damage due to thrips was higher on 04.08.2006 (47.5) followed by 32.5 (20.07.2006 and 25.11.2006). However, 4 per cent PBND was recorded on 02.09.2006 and the thrips were identified as *Caliothrips indicus* and *Scirtothrips dorsalis*.

At Junagadh, thrips population ranged from 1.00 to 4.00 thrips/ 10 plant (terminal leaves). The incidence of thrips commenced from second week of July and continued up to harvest. Maximum thrips population was recorded in second week of July. Population of thrips pest was slightly declined and again reached to second peak of 2.5 thrips/ 10 plants in 4th week of August and 1st week of September. The correlation study indicated that thrips population exhibited positive correlation with maximum and minimum temperature Cr= 0.2031 and 0.1286, respectively, whereas, other factors *viz.*, humidity, rainfall and rainy days showed negative correlation on incidence of thrips.

4. Front Line Demonstrations

A total of 467 Front Line Demonstrations (FLDs) were allotted on eight different components during *kharif*-2006 to 16 centers in the major groundnut growing states like Andhra Pradesh, Gujarat, Manipur, Karnataka, Maharashtra, Orissa, Rajasthan, Tamil Nadu and Uttar Pradesh.

The results of 255 FLDs from fifteen centres on improved variety indicated that on an average, improved cultivars increased pod yield by 26.7% over the local cultivar. The highest increase in pod yield of 52.3% by improved variety (Narayani) was recorded at Tirupati centre over local cultivar. Chintamani center recorded 47.8% increase in pod yield of GPBD-4 over the local cultivar (local red/TMV-2).

The results of 42 FLDs on INM at five centres indicated that by adopting INM package 19.5% increase in pod yield over the farmers' practice could be realized. The highest increase in pod yield of 25.4% at Junagadh followed by 21.3% at Jalgaon was recorded over the farmers' practice.

The results of thirty-two FLDs on Integrated Pest Management showed that there was an increase in pod yield by 17.9% over the farmer's practice of pest management. The highest increase in pod yield of 26.9% over the farmers' practice was recorded at Chintamani followed by Vriddhachalam 24.4%. The yield increase of 18.4% at Junagadh, and 14.9% at Jalgaon was recorded due to adoption of IPM package over the farmers' practice.

Integrated disease management (IDM):- The results of twenty-six FLDs at two centers (Junagadh & Aliyarnagar) showed that on an average 23.9% increase in pod yield was observed over the farmers' practice. The highest increase (24%) in pod yield was recorded at Junagadh closely followed by 23.8% at Aliyarnagar over the farmers' practice of disease management.

Ten FLDs organized on PGPR at Aliyarnagar indicated that the pod yield increase was to the tune of 19.3% due to the application of PGPR over the control (no PGPR).

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Particpation in meetings and training s

Dr. K. K. Pal

1. Worked during 06.01.2006 to 05.01.2007 on deputation at the Department of Plant Pathology, the Ohio State University-OARDC, Wooster, Ohio, USA for availing DBT Long Term Overseas Associateship Award Programme 2004-05.

Dr. Vinod Kumar

1. Training Programme on "Bioinformatics in conservation of microorganisms" from 1st May to 8th May 2006 jointly organized by National Bureau of Agriculturally Important Microorganisms (NBAIM) and National Chemical Laboratory (NCL), Pune and held at, NBAIM Mau, U.P.
2. ACIAR Regional Workshop on "Minimizing Aflatoxin Risk in Peanuts" held at ICRISAT Center, Patancheru, India during 21-22 February 2007.
3. Six-monthly Review Meeting of the Mycotoxin Network Project at RARS, Tirupati (ANGRAU) during July 7th - 8th 2006.
4. Annual *Rabi*/Summer Groundnut Workshop held at NRCG, Junagadh, during 18-19th September 2006

Dr. T.V. Prasad

1. Training on "Advances in microbial control of insect and mite pests" organized by Project Directorate of Biological Control, Bangalore from 9th to 18th November 2006.

2. CAS training on "Recent Advances in Host Plant Resistance to Insect and Mite pests" organized by Center for Advances studies in Entomology, Tamil Nadu Agricultural University Coimbatore from 3rd to 23rd January, 2007.

3. National Seminar on "Changing Global Vegetable Oils Scenario: Issues and Challenges before India" held at DOR, Hyderabad during January 29-30, 2007.

4. National Conference on "Organic Waste Utilization and Eco-friendly Technologies for Crop Protection" organized by NBPGR (RS), Rajendranagar, Hyderabad during March 15-17, 2007.

5. *Kharif* groundnut workshop, during 28-30 April 2006 at MPKV Rahuri.

6. *Rabi*/Summer groundnut workshop during September 17- 19, 2006 at NRCG, Junagadh

Short Course/ Training / Review meetings organized

Dr. Vinod Kumar

1. Short Course cum Hands on Training Programme on "Management of Aflatoxins in Groundnut", 20th-29th November 2006, funded by ICAR..

2. Six-monthly Review Meeting of the Mycotoxin Network Project at RARS, Tirupati (ANGRAU), July 7th - 8th 2006.

List of employees (as on 01.04.2006)

Sr. No.	Name	Designation
1.	Dr. M.S.Basu	Director
2.	Dr. M.P. Ghewande	Principal Scientist
3.	Dr. I. K. Girdhar	Principal Scientist
4.	Dr. J. B. Misra	Principal Scientist
5.	Dr. P. C. Nautiyal	Principal Scientist
6.	Dr. A. L. Singh	Principal Scientist
7.	Dr. T. Radhakrishnanan	Principal Scientist
8.	Dr. A. L. Rathanakumar	Senior Scientist
9.	Dr. Chuni Lal	Senior Scientist
10.	Dr. S. K. Bera	Senior Scientist
11.	Dr. K. K. Pal	Senior Scientist
12.	Dr. Rinku Dey	Senior Scientist
13.	Sh. G. Govindraj	Scientist
14.	Sh. G. D. Satishkumar	Scientist
15.	Dr. Hariprasanna K	Scientist
16.	Dr. Vinod Kumar	Scientist
17.	Dr. T. V. Prasad	Scientist
18.	Sh. V. V. Sumanthkumar	Scientist
19.	Dr. R.S. Tomar	Farm Superintendent, T6
20.	Sh. M.M. Dash	Technical Officer, T6
21.	Ms. S.M. Chauhan	Technical Officer, T6
22.	Sh. V. K. Sojitra	Technical Officer, T6
23.	Sh. C. P. Singh	Technical Officer, T6
24.	Smt. V. Girdhar	Technical Officer, T6
25.	Dr. D. L. Parmar	Technical Officer, T6
26.	Sh. D. M. Bhatt	Technical Officer, T6
27.	Sh. H. B.Lalwani	Technical Officer, T6
28.	Sh. H. M. Hingrajia	Technical Officer, T6
29.	Sh. N. R.Ghetia	Technical Officer, T6
30.	Sh. P. V. Zala	Technical Officer, T6
31.	Sh. Ranvir Singh	Technical Officer, T6
32.	Dr. S. D. Savaliya	Technical Officer, T6
33.	Mrs.V. S. Chaudhari	Technical Officer, T5
34.	Sh. Virendra Singh	Technical Officer, T5
35.	Sh. V. G. Koradia	Technical Officer, T6
36.	Sh. P. K. Bhalodia	Technical Officer, T5

37.	Sh. B. M. Chikani	Technical Officer, T5
38.	Sh. D. R. Bhatt	Technical Officer, T5
39.	Sh. H. K. Gor	Technical Officer, T6
40.	Dr. J. R. Dobaria	Technical Officer, T6
41.	Dr. M. V. Gedia	Technical Officer, T5
42.	Sh. P. R. Naik	Technical Officer, T5
43.	Sh. A.D. Makwana	Technical Assistant, T-4
44.	Sh. H. V. Patel	Technical Assistant, T-4
45.	Sh. Prabhu Dayal	Technical Assistant, T-4
46.	Sh. R. D. Padvi	Technical Assistant, T-4
47.	Sh. Suraj Pal Singh	Technical Assistant, T-4
48.	Sh. V. K. Jain	Technical Assistant, T-4
49.	Sh. G. J. Solanki	Technical Assistant, T-3
50.	Sh. C. B. Patel	Technical Assistant, T-3
51.	Sh. P. B. Garchar	Technical Assistant, T-3
52.	Sh. J. G. Kalaria	Technical Assistant, T-3
53.	Sh. K. H. Koradia	Technical Assistant, T-3
54.	Sh. Sugad Singh	Technical Assistant, T-3
55.	Sh. A. M. Vakharia	Technical Assistant, T-3
56.	Sh. B. M. Solanki	Technical Assistant, T-3
57.	Sh. G. G. Bhalani	Technical Assistant, T-3
58.	Sh. N. M. Safi	Technical Assistant, T-3
59.	Sh. Pitbas Das	Technical Assistant, T-3
60.	Sh. S.K. Ghosh	Administrative officer
61.	Sh. Arvind	Finance and Accounts Officer
62.	Sh. Dilip Kar	Assistant Administrative Officer
63.	Sh. J. B. Bhatt	Assistant
64.	Smt. Rosamma Joseph	Senior Stenographer
65.	Sh. R. T. Thakkar	Assistant
66.	Sh. Y. S. Karia	Stenographer
67.	Sh. L. V. Tilwani	Stenographer
68.	Ms. S. Venugopalan	UDC
69.	Ms. M. N. Vaghasia	UDC
70.	Sh. R. D. Nagwadia	LDC
71.	Sh. C. G. Makwana	LDC
72.	Sh. H. S. Mistry	LDC
73.	Sh. M. B. Kher	Security Supervisor
74.	Sh. N. M. Pandya	SSG 4

75.	Sh. D. M. Sachania	SSG 4
76.	Sh. R. B. Chawada	SSG 3
77.	Sh. B. K. Baria	SSG 3
78.	Sh. C. N. Jethwa	SSG 3
79.	Sh. R. V. Purohit	SSG 2
80.	Sh. M. B. Sheikh	SSG 2
81.	Sh. J . G Agrawat	SSG 2
82.	Sh. K. T. Kapadia	SSG 2
83.	Sh. V. N. Kodiatar	SSG 2
84.	Sh. R. P. Sondarwa	SSG 1
85.	Sh. P. N. Solanki	SSG 1
86.	Sh. V. M. Chawda	SSG 1
87.	Sh. G. S. Mori	SSG 1
88.	Smt. D. S. Sarvaiya	SSG 1
89.	Sh. P. M. Solanki	SSG 1
90.	Sh. A. D. Makwana	SSG 1
91.	Sh. N. G. Vadher	SSG 1
92.	Sh. B. J. Dabhi	SSG 1

CATEGORY WISE CADRE STRENGTH

Total staff in NRCG, and employees belonging to SC, ST, and OBC as on 31.3.07

Category	Sanctioned	In position	SC	ST	OBC
Scientific	40	18	1	0	4
Technical	39	39	5	4	3
Administration	13	13	2	0	3
Supporting	19	18	5	3	7
Total	**111**	**88**	**13**	**7**	**17**

PROMOTIONS

Through Departmental Promotion Committee

Scientific (meeting held on 21.07.2006)

Sl. No.	Name	From	To
1	Dr. Chuni Lal	Scientist	Sr. Scientist

Technical (meeting) held on 03.07.2006)

Sl. No.	Name	From	To
1	Shri H.K. Gor	T-5	T-6
2	Shri Ranvir Singh	T-5	T-6
3	Dr.J.R. Dobaria	T-5	T-6
4	Dr.S.D. Savalia	T-5	T-6
5	Shri H.M. Hingrajia	T-5	T-6
6	Shri P.B. Garchar	T-2	T-3

Through assessment by ASRB under Career Advancement Scheme

Sl. No.	Name	From	To	Date
1	Dr. Radhakrishnan T.	Sr. Scientist	Pr. Scientist	27.7.2006

IMC Meeting

Institute Management Committee Meeting was held on 14.6.2006.

Transfer

1 Shri S.K. Ghosh, Administrative Officer to IVRI, Regional Station. Bangalore on 30.12.2006

Superannuation

1. Sh. M.M. Dash, T6 on 31.12.2006

FINANCE AND ACCOUNTS
EXPENDITURE STATEMENT FOR THE YEAR 2006-07

Rupees in lakhs

NRCG-Main Unit

Sl No.	Budget Head	Non-Plan BE	Non-Plan RE	Non-Plan Expenditure	Plan BE	Plan RE	Plan Expenditure
1	Estt. charges	190.00	194.50	188.55	0.00	0.00	0.00
2	OTA	0.10	0.00	0.00	0.00	0.00	0.00
3	Wages	14.50	17.00	17.02	0.00	0.00	0.00
4	TA	4.50	4.50	4.50	11.00	3.77	3.73
5	HRD	0.00	0.00	0.00	0.00	0.00	0.00
6	Other charges including equipment/vehicles	22.90	28.00	27.86	130.00	139.23	104.18
7	Works	16.00	6.00	6.00	28.00	85.00	42.38
8	Other items (NEH Region)	0.00	0.00	0.00	1.00	0.00	0.00
	Total	248.00	250.00	243.93	170.00	228.00	150.29

Rupees in lakhs

AICRP-G

S.No.	Budget Head	Allocation	Expenditure
1	Pay and Allowances	204.70	204.70
2	TA	6.90	6.90
3	Contingency	27.60	27.60
4	HRD	3.00	0.22
5	Need based Research	12.80	3.65
	Total	255.00	243.07

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