Annual Report
2004-05

National Research Centre for Medicinal and Aromatic Plants
Boriavi, Anand - 387 310, Gujarat, India

ANNUAL REPORT
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National Research Centre for Medicinal and Aromatic Plants

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PREFACE

Today, everyone in the world is convinced that treatment of the fatal diseases such as cancer, HIV, AIDS, etc can not be achieved by one system alone. Integration of Complimentary and Alternative Medicine (CAM) with modern medicine is thereby increasing in a faster pace. Many unconventional approaches of treatments are now becoming extraordinarily popular. Western world has now recognised the importance of herbal medicines, herbal food supplements, vitamins, prayers, meditation, pranayam, spiritual life, etc. as combination treatment for many fatal diseases including cancer and heart diseases. Meditation is gradually accepted for bringing the person back to the normal life as post operational measures. Of late, world is recognising the 5000 years' old Indian wisdom in treating the diseases i.e., target the root of diseases by holistic approach not by treating the symptoms. Symptoms are the manifestations of disturbed mind, body and soul.

According to Ayurveda, medicinal substances and living bodies are similar in composition. Hence herbs and drugs influence the body according to their nature and attributes. All Ayurvedic treatments, therefore, attempt to establish a balance among the bodily elements i.e., ***vata, pitta*** *and* ***kapha****. According to* ***Charaka****, medicines are those substances that, after entering the body, get eliminated through gastro-intestinal tract within a certain period after their corrective role is over. Sometimes there will be overlap between medicines and foods i.e., foods also have medicinal properties and medicines have also tissue building action.*

Herbal drugs for the treatment of diseases are of different types. It may be alterative or blood purifier, which destroy toxins. These herbs are used fresh along with a detoxifying diet. Second category of herbs is circulatory stimulants and promotes blood circulation and aid in the healing of tissues. These herbs affect all the three bodily ***elements****. Third category of herbs is immune strengthening tonics which is better in debility conditions. The fourth category of herbs includes special expectorants. Besides these categories, there are also herbs which are pungent or bitter which have fat reducing and toxin destroying properties.*

Thus, in this changing health scenario where herbal therapies are becoming more and more acceptable, agriculture plays an important role in maintaining the quality of herbal drugs by growing right plant type and harvesting at optimum stage. The NRCMAP has taken the lead in developing superior varieties and good agricultural practices for a number of medicinal and aromatic plants. Its out reach programme named All India Networking Research Project on Medicinal and Aromatic Plants is also contributing in this endeavour and expanding our area of research. Results of experiments carried out during 2004-05 are presented in this annual report. I am sure it will be useful for research and farming communities.

I take this opportunity to place on record my sincere gratitude to our Director General, Dr. Mangala Rai and Deputy Director General, Dr. Gautam Kallo for their keen interest and support in developing the institution of repute. I thank Dr. Pandey, ADG (Hort.) and Dr. Ramana, ADG (PC) for their support in dealing various issues in the headquarters. Thanks are also due to all the scientists of NRCMAP and AINPs on MAP and Betelvine for their timely submission of work done report. Help rendered by my colleagues, Dr. Manish Das, Mr. Kunal Mandal, Ms. K. A. Geetha and Mr. Saravanan Raju in compilation of the results and Ms. P. U. Pandit for Hindi translation are also gratefully acknowledged.

Anand,
November 30, 2005

Satyabrata Maiti

सारांश

राष्ट्रीय औषधीय एवं सुगंधीय पादप अनुसंधान केन्द्र तथा इसके दस, राज्य-कृषि विश्वविद्यालयों में स्थित अखिल भारतीय तंत्र परियोजना केन्द्र, औषधीय एवं सुगंधीत पौधों पर संशोधन कार्य में कार्यरत है । जाति अनुसार महत्वपूर्ण अनुसंधान उपलब्धियाँ निम्नलिखित है ।

अनुसंधान उपलब्धियाँ

औषधीय पोधे

धृतकुमारी

सभी सूचकांको में से सूचकांक एन.एम.आर-२ में अधिक एलोइन-ए पाया गया । प्रक्षेत्रमें संवर्धनदर कम होने के कारण इस वंशक्रम का रा. औ.सु.पा.अ.के. में सुक्ष्म-संवर्धन के लिए प्रयत्न किया गया । प्रकांडकलिका को पृष्ठ रोगाणुंनाशन करके प्रयोगशाला में अधिक उत्पादन हेतु उपयोग में लिया गया । परिणाम सूचित करते है क बी.ए., आई.ए.ए. और सुक्रोस की भिन्न सांद्रतावाले १/२ बेझल मिडीयम पर दो सप्ताह के संवर्धन के बाद सिर्फ एक प्रकांडकलिका से २८ प्रकांडकलीका प्राप्त करना संभव हुआ ।

असगंध

हिसार में कुल जैविक उत्पाद प्रति पौधा में ६३.४ से ३०८.४ ग्राम की भिन्नता पाई गई । वंशक्रम डबल्यु एस-९०-१२५ (२५ ग्राम प्रति पौधा), डबल्यु. एस.-२१८ (२६.५ ग्राम प्रति पौधा), के बाद जी.पी.-२७-लोकल में महत्तम जड़ उत्पाद दर्जित हुआ, जब कि चेक-जे.ए.-२० का उत्पाद (१५ ग्राम प्रति पौधा) था । १२ कि.ग्रा. प्रति हेक्टर के बीजदर से महत्तम ३५४२ एवं ८२८ कि.ग्रा. प्रति हेक्टर ताजी एवं सूखी जड़ पायी गयी ।

मंदसौर में १४ विभिन्न गुणों के लिए अशगंध की ६२ पंक्तियाँ मानाकित की गई । पंक्तियों में व्यापक स्तर की भिन्नता पायी गयी । सूखी जड़ उत्पाद में प्रविष्टियाँ एम डबल्यु एस-३०८, एम डबल्यु एस-३२४ और जे.ए.-१३४ उच्चतम पायी गयी । इसी तरह (एम डबल्यु एस-३३३) २२२ कि.ग्रा. प्रति हेक्टर से (एम डबल्यु एस-३०८ और जे.ए.-१३४) ६९४ कि.ग्रा. प्रति हेक्टर तक पाया गया । एम. डबल्यु. एस.-३३३ (०.६%) महत्तम अल्कलाइड तत्व (०.६८%) जे.ए.-१३४ में था । केंचुए की खाद देने से महत्तम उत्पादन ६४२ कि.ग्रा. प्रति हेक्टर पाया गया ।

उदयपुर में जड़ उत्पाद में जे.ए.-१३४ के उपर जे.ए.-२० उच्चतम पायी गयी । ८ कि.ग्रा. प्रति हेक्टर बीजदर से सूचकरूप से महत्तम १२९० कि.ग्रा. प्रति हेक्टर ताजी एवं ४६५ कि.ग्रा. प्रति हेक्टर सूखी जड उत्पादित हुइ । सूचकरूप से महत्तम जड उत्पादन १६२५ कि.ग्रा. प्रति हेक्टर के लिए बुआई दिनांक २ सितंबर और कटाई दिनांक २ अप्रैल दर्जित है । सभी बुआई दिनांक में फसल की आयु के साथ कुल अल्कलाइड तत्व में भी बढोतरी हुई है ।

अकोला में महत्तम जड उत्पाद ५६३ कि.ग्रा. प्रति हेक्टर १००% फूल आने की अवस्था में दर्जित किया गया । सूचकरूप से कुल अल्कलाइड तत्व ३५० कि.ग्रा. प्रति हेक्टर १००% फूल आने की अवस्था में पाया गया ।

चन्द्रसूर

चन्द्रसूरकी नौ जनीनद्रव्य पंक्तियों का बीज उत्पाद तथा उसके गुणों के लिए परीक्षण किया गया । एम एल एस-३ (१७०३ कि.ग्रा. प्रति हेक्टर) एवं एम.एल.एस.-१ (१८२३ कि.ग्रा. प्रति हेक्टर) के बाद एम.एल.एस.-७ (२०६६ कि.ग्रा. प्रति हेक्टर) में महत्तम बीज उत्पादन अन्य प्रविष्टियों से सूचकरूप से उच्चतम था । रा.औ.सु.पा.अ.के. में महत्तम बीज उत्पाद ६५८ कि.ग्रा. प्रति हेक्टर ०६ आई डबल्यु : सी.पी.ई. में दर्जित हुआ जो ८.० और १.० आई. डबल्यु : सी.पी.ई (क्रमानुसार ६०९ एवं ६०२ कि. ग्रा. प्रति हेक्टर) के सममूल्य था ।

शतावर

हिसार में प्रतिपौधा गुच्छेदार जड का वजन ०.५७ से १.३९ कि.ग्रा. और सेपोनीन तत्व ४.५० प्रतिशत से लेकर ५.३४ प्रतिशत पाया गया । महत्तम गुच्छेदार जड उत्पाद प्रतिपौधा एच ए आर-६ (०.९१ कि.ग्रा.), एच. ए. आर.-२ (०.९९८ कि.ग्रा.) और एच. ए. आर.-३ (१.२३ कि.ग्रा.) के बाद एच ए. आर.-७ (१.३९ कि.ग्रा.) पाया गया । बुआई दिनांक और बीजदर के परस्पर प्रभाव से यह सार्थक हुआ कि २४ जूनकी बुआइ दिनांक और ६.० कि.ग्रा. प्रति हेक्टर के बीजदर से सूचकरूप से महत्तम (८८७३४ कि.ग्रा. प्रति हेक्टर) ताजा गुच्छेदार जड उत्पाद दर्जित हुआ है । अकोला में खुलेपात्र में अवन में सूखाये गये नमूने (०.६%) के बाद महत्तम सेपोनीन वायुरोधी पात्र में रखकर अवन में सूखाये गये नमूने (०.६%), दोनो सममूल्य है ।

चिरायता

सोलन में कटुपदार्थ के निष्कर्षण और मूल्यांकन की पध्धति मानाकित की गई । प्रक्षेत्र में उगाये गये पौध से इकटठी की गइ मूलज पत्तीयों को छांव में सूखाकर निष्कर्षण किया गया ।

इसबगोल

हिसार में पी-७९ (६.१ ग्राम), पी. एस. - १९ (६.२ ग्राम), डी. एम. - ७ (६.३ ग्राम), पी.बी.-१०-४ (६.५ ग्राम) और पी-९६ (६.९ ग्राम) के बाद वंशक्रम इ. सी. - ४११८१-३७ (७.२ ग्राम) में महत्तम बीज उत्पादन प्रति पौध दर्जित किया गया जब कि उत्तम चेक जी. आई. - १ का बीज उत्पाद मूल्य ४.७ ग्राम प्रति पौध दर्जित है । मंदसौर में शोथ तत्व मीली प्रति ग्राम ६.० (एस. पी. एस. - १९) से लेकर ९.६ (एस. एल. एस. - १६) और ५० प्रतिशत फूल आने की अवस्था के दिन ५६ (एस. एल. एस. - १६) और ६९ (एस. एल. एस. - १६) थे । बीज उत्पाद २९७ कि.ग्रा. प्रति हेक्टर (एस. एल. एस. - ६५) से लेकर १४५० कि.ग्रा. प्रति हेक्टर (एस. एल. एस. - ५९) था । २१ नवंबर को बुआई करने से सूचकरूप से महत्तम बीज उत्पादन (८३४ कि.ग्रा. प्रति हेक्टर) हुआ । महत्तम बीज उत्पादन ३ सिंचाइ से (८३४ कि.ग्रा. प्रति हेक्टर) और २ सिंचाइ से (६८७ कि.ग्रा. प्रति हेक्टर) हुआ ।

अकोला में २० नवंबर को बुआई करने से सूचकरूप से महत्तम बीज उत्पादन ३६६० कि.ग्रा. प्रति हेक्टर हुआ । उदयपुर में अन्य की तुलना में सिंचाई (अंकुर की शुरुआत में + पूर्ण अंकुरित + फूल आने की अवस्था में) देने से महत्तम बीज उत्पाद (१४६८ कि.ग्रा. प्रति हेक्टर) और तिनका उत्पादन (३०३१ कि.ग्रा. प्रति हेक्टर) हुआ । ०.२ पीपीएम (१०२३ कि.ग्रा. प्रति हेक्टर) बीज और तिनका उत्पाद (२३२३ कि.ग्रा. प्रति हेक्टर) और कंट्रोल (८६४ कि.ग्रा. प्रति हेक्टर और २१३५ कि.ग्रा. प्रति हेक्टर तिनका) की तुलना में ०.४ पीपीएम ब्रासीनोस्टीरोइड का छिडकाव करने से महत्तम बीज उत्पाद (११८९ कि.ग्रा. प्रति हेक्टर) और तिनका उत्पाद २४६१ कि.ग्रा. प्रति हेक्टर) मिला ।

रा.औ.सु.अ.के. पर दो जैवप्रेरणात्मक दिनांक नवंबर १५ और २५ और चार अन्य दिनांक (नवंबर १२,

२० और २८) सेन्द्रिय आधारित कृषि तकनीक विकसित करने के लिए मान्य की गई । बुआईके ३०, ६० और ९० दिन बाद परिणाम मानाकित किए गए है कि पौध-विकास पौध रोपण दिनांक से प्रभावित नहीं होता । पहली बुआईओं में बीज उत्पाद १३५३ से १२०६ कि.ग्रा. प्रति हेक्टर तक पाया गया जो सममूल्य था । नवंबर २८ को बुआई करने से सूचकरूप से कम बीज उत्पाद ९३४ कि.ग्रा. प्रति हेक्टर उत्पादित हुआ । ९ नवंबर को बुआई करने से महत्तम तिन का उत्पादन (१०२५८ कि.ग्रा. प्रित हेक्टर) दर्जित हुआ । जैवप्रेरणात्मक दिनांक का सूचकरूप से विकास, क्रियात्मकता, रोगउपद्रव एवं उत्पाद पर कोई असर नहीं होता । वानस्पतिक मिश्रण और पंचगव्य के छिडकाव से स्पाइक की लंबाइ और खाली स्पाइक की संख्या में प्रति पौधा कोई असर नहीं हुआ । फिर भी बीज और तिनके का उत्पाद तथा उत्पादक्रम सूचकरूप से इस उपचार से प्रभावित हुए । रोग से पहले एक (१२७० कि.ग्रा. प्रति हेक्टर) और दो (१४०३ कि.ग्रा. प्रति हेक्टर) या तो, रोग के बाद एक (१३३४ कि.ग्रा. प्रति हेक्टर) वानस्पतिक मिश्रण के छिडकाव से एवं पंचगव्य (१२९४ कि.ग्रा. प्रति हेक्टर) के छिडकाव से सूचकरूप से कंट्रोल की तुलना में बीज उत्पाद (१०८८ कि.ग्रा. प्रति हेक्टर) बढा है । गोबरखाद के उपयोग से असेन्द्रिय और जैविकखाद के साथ नत्रजन के उपयोग की क्षमता बीज में २.१% से २.१४% तक और तिनके में ०.६७% से ०.७१% बढी ।

कालमेघ

भारत के भिन्न भिन्न जगहों से कालमेघ के ६ सूचकांक लाये गये औ आनन्द में गुणवत्तायुक्त उत्पाद के लिए मानाकित किए गए । सूचकरूप से सूचकांक ३ में अधिक उत्पाद (२८४४ कि.ग्रा. प्रति हेक्टर) पाया गया । जबकि शोध किए गए सूचकांको में एन्ड्रोग्राफेलोइड तत्व में बदलाव का कोई भी पौध नही पाया गया ।

रा.औ.सु.अ.के. पर ४३ सूचकांको को पौध उचाइ, शाख संख्या, पौध फेलाव, पौध उत्पाद एवं एन्ड्रोग्राफेलोइड तत्व के आधार पर मानाकित किया गया और महसूस किया गया कि ताजा एवं सूखा उत्पाद आईसी ३४२१३६ में (२९०.६ ग्राम प्रति पौध और ९९.१६ ग्राम प्रति पौध) महत्तम और आईसी १११२८६ में (१२०.८ ग्राम प्रति पौध और ३२.१२ ग्राम प्रति पौध) लघुत्तम पाया गया । तने में एन्ड्रोग्राफेलोइड तत्व (%) महत्तम आईसी २६००३५ और आईसी २१०६३५ में (०.३६५) और लघुत्तम आईसी ३४२१४१ में (०.०९) था । जबकि पत्ती में एन्ड्रोग्राफेलोइड तत्व आईसी ३४२१४१ में (०.६७%) और लघुत्तम (१.२८१%) भुवनेश्वर के सूचकांक में था ।

मुलेठी

हिसार में वंशक्रम चेक एच.एम.-१ (९४.४४ किव. प्रति हेक्टर) के सापेक्ष में वंशक्रम एच.एम. के.-७-५ (१०५.५५ किव. प्रति हेक्टर), एच.एम.के.-१-२ (१०८.३३ किव. प्रति हेक्टर), एच.एम. के.-७-४ (१११.११ किव. प्रति हेक्टर), एच.एम.के. - ७-१(१२५.० किव. प्रति हेक्टर) और एच.एम. के.-१-३ (१३६.११ किव. प्रति हेक्टर) के बाद एच.एम.के. - ६-२ (१६१.११ किव. प्रति हेक्टर) में अधिक भूस्तारी उत्पाद पाया गया ।

अफीम

फैजाबाद में विभिन्न केन्द्रों से लाये गये ११८ जनीन द्रव्यों को ४ चेक के साथ मानाकित किया गया । महत्तम क्षीर उत्पाद वंशक्रम १३८५ (४२.७० कि.ग्रा. प्रति हेक्टर) में दर्जित हुआ । महत्तम बीज उत्पाद वंशक्रम (एन.ओ.पी.-०३-१ (९५८ कि.ग्रा. प्रति हेक्टर) और महत्तम भूसी उत्पाद एन.डी.-२० (८३३ कि. ग्रा. प्रति हेक्टर) में दर्जित हुआ । मंदसौर में क्षीर उत्पाद ११.९१ कि.ग्रा. प्रति हेक्टर (आई.सी.-१९) से

७७.४५ (एम.ओ.पी.-१०६९) तक और बीज उत्पाद (कि.ग्रा. प्रति हेक्टर), आई.सी.-९५ में १२०८ कि. ग्रा. से १९४९ कि.ग्रा. (एन.बी.आर.आइ.-५) तक पाया गया । मोर्फीन प्रतिशत १२.४ से १७.३ तक और थीबेइन तत्व एम.ओ.पी.-१०७४ में कम, एम.ओ.पी.-५७५ में मध्यम तथा एम.ओ.पी.-५१३ में अधिक दर्जित हुआ है । महत्तम क्षीर उत्पाद ७५% नत्रजन, गोबरखाद में मिलाकर देने से और अन्य उपचारों में ७५% नत्रजन कृमिखाद में मिलाकर देने से महत्तम क्षीर उत्पाद (२१.४२ कि.ग्रा. प्रति हेक्टर) दर्जित हुआ है । कृमिखाद के उपचारों में से महत्तम बीज उत्पाद (६५९ कि.ग्रा. प्रति हेक्टर) और भूसी उत्पाद (५१७ कि.ग्रा. प्रति हेक्टर) १००% सेन्द्रिय स्तोत्र से पाया गया ।

कुल ११० वंशक्रम का प्रक्षेत्र वातावरण में डाउनी माइल्डयु प्रतिरोधकता के लिए पृथ्थकरण किया गया और उसे चार शृंखला में वर्गीकृत किया गया । अमोर्फीक आल्कलोइड जैसे कि, थीबेइन और कोडीन की मांग बढने पर मंदसौर में ५० पंक्तियों को उनके आल्कलोइड तत्व के आधार पर मूल्यांकन करने का प्रयत्न किया गया । कुछ पंक्तियों में अधिक सांद्रतावाले एक से ज्यादा आल्कलोइड पाए गये । आईसी-११४ और एम.ओ.पी.-५४१ में अधिक सांद्रतावाले सभी तीन आल्कलोइड थे ।

सफेद मूसली

रा.औ.सु.पा.अ.के. में ताजा गुच्छेदार जड उत्पाद गुज.-१ में ५.७७ ग्राम प्रति पौध से लेकर राज.-११ में २३.७७ ग्राम प्रति पौध तक था । महत्तम मांसलकंद प्रति पौध की संख्या गुज.-२ में (२०.४३ ग्राम) और लघुत्तम गुज.-१ में ४.३० ग्राम थी । मांसलकंद की लंबाई (गुज.-१) १.९७ से लेकर (एम.पी.-४) ९.२६ से.मी. तक थी । एन.बी.पी.जी.आर. में आई.एन.जी.आर. नं. ०४११३ और आई.एन.जी.आर. नं. ०४११४ से पंजीकृत की गइ दो पंक्तियाँ (एन.आर.सी.सी.बी.-१ और एन.आर.सी.सी.बी.-२) रा.औ.सु.पा.अ.के. में विकसित की गइ । महत्तम प्रकांड पाने के लिए पेशी संवर्धन वातावरण में बी.ए., के.एम., एन.ए.ए., आई.ए.ए. और एडीनीन सल्फेट वाले १/२ एम.एस. मिडीयापर प्रकांड मंडल पर अंकुरित प्रकांड-कलिका का उपयोग किया गया । बी.ए और एडीनीन-सल्फेटयुक्त मिडीयम से झडपी प्रकांड-समापवर्त्य पाने में मदद हुई । प्रकांड-समापवर्त्य दर, भिन्न मात्रा में बी.ए.,एडीनीन सल्फेट और एन.ए.ए. वाले मिडीयम पर महत्तम था । यह शोध से ४ सप्ताह में महत्तम (११.२) प्रकांड प्रति संवर्धन से उत्पादित हुआ ।

आनन्द में पौधों से पुष्पक्रम नियमितरुप से पौधों से पुष्पक्रमदूर किया गया । पुष्पक्रमदूर करने से वानस्पतिक विकास, उत्पाद संबंधी परिमाण और मांसलकंद उत्पाद में बढोतरी हुई । कंट्रोल के उपर पुष्पक्रमदूर किए गए पौधों से सूचकरूप से अधिक मांसलकंद उत्पाद ३१.७०% दर्जित हुआ । ५१३६.१९ कि.ग्रा. प्रति हेक्टर की तुलना में, पुष्पक्रमदूर करने के बाद मांसलकंद उत्पाद ६७६४.५६ कि.ग्रा. प्रति हेक्टर था । भिन्न पौध संख्या सूचकरुप से ताजा मांसलकंद उत्पाद पर प्रभावित है । १०X१० से.मी. अंतर रखने से, महत्तम मांसलकंद उत्पाद ११८५५ कि.ग्रा. प्रति हेक्टर पाया गया । अधिक ताजा मांसलकंद के उत्पाद से कुल महत्तम आय बढकर रु. २२६५४०० लघुत्तम अंतर से, और रू. १३४३८०० लघुत्तम १०X१० से.मी. अंतर से दर्जित हुई । फिर भी महत्तम खर्च : मुनाफा गुणांक (१:६:१६), लघुत्तम पौध संख्या में था ।

उदयपुर में उपजाति एम.सी.बी.-४१२ (६०६४ कि.ग्रा. प्रति हेक्टर) की तुलना में उपजाति एम.सी. बी.-४०५ से सूचकरूप से अधिक ताजा मांसलकंद उत्पाद (६६५७ कि.ग्रा. प्रति हेक्टर) पाया गया । लघुतम अंतर से सूचकरूप से महत्तम मांसलकंद (७७८३ कि.ग्रा. प्रति हेक्टर) उत्पादित हुआ । उपजाति एम.सी.बी.-४०५ को पौध से पौध १० से.मी. की दूरी पर लगाने से महत्तम मांसलकंद (७९५२ कि. ग्रा. प्रति हेक्टर) पाया गया । इसी तरह उपजाति एम.सी.बी.-४०५ को लघुत्तम दूरी पर लगाने से सूखा जड उत्पाद सूचकरूप से महत्तम (१५९० कि.ग्रा. प्रति हेक्टर) दर्जित हुआ । भिन्न प्रकार की पौध रोपाई

पद्धति अपनाने से सभी उत्पाद संबंधी गुणों और ताजा मांसलकंद उत्पाद मेंढ पर रोपाई में महत्तम दर्जित हुआ । ताजा मांसलकंद उत्पाद मेंढ पर रोपाई में महत्तम (१६४५ कि.ग्रा. प्रति हेक्टर) था । सेपोजेनीन तत्व ६.६८ से ६.६९% तक भिन्न था जो सूचकरूप से पौध रोपाई पद्धति से भिन्न नहीं था ।

अकोला में मांसलकंद पाउडर के संग्रह से सेपोनीन तत्व की गुणवत्ता में कमी हुई । सूचकरूप से लघुत्तम तत्व १२ महीनों के संग्रह से (५.७९%) दर्जित था । महत्तम (६.१३%) सेपोनीन वायुरोधी पात्र में रखे हुए पदार्थ को अवन में सूखाने से पाया गया ।

मंदसौर में मांसलकंद सडनरोग के सही नियंत्रण का विकास करने के लिए मृदा में ६० कि.ग्रा. प्रति हेक्टर पोटाश और ट्राइकोडर्मा वीरीडी ५ कि.ग्रा. प्रति हेक्टर के दर से देने से और/अथवा बीज को शोधित करने के लिए ०.१५% के दर से बावीस्टीन या तो सिर्फ एक अथवा भिन्न संयोजनो का उपयोग किया गया । पोटाश, ट्राइकोडर्मा और बावीस्टीन के संयोजित शोधन से सूचकरूप से लघुत्तम १४.१५% मांसलकंद सडन उत्पन्न हुआ ।

शंखपुष्पी

रा.औ.सु.पा.अ.के. में पौध प्रकार, पंखडी-प्रकार, पंखडी-रंग इत्यादि में भिन्नता और जनन-जीवशास्त्र के साथ साथ पौध जाति के प्रजनन-गतिविधी परभी अभ्यास किया गया । पौधसमूह में से तीन प्रकार के पौधों की पुष्पक्र के प्रकार के आधार पर पहचान की गई, जैसे कि दंडयुक्त (दंडीय) अथवा अचल (अदंडीय) पुष्पक्रम अथवा दोनों दंडीय और अदंडीय पुष्पक्रम (मध्यवर्ती) । पुष्प के रंग की विशेषता में बहुरूपीता भी दर्जित की गई । तीन स्पष्ट रंग-प्रकार दर्जित हुए । भिन्न प्रकार के पंखडी-आकार पाए गये जैसे कि तीक्ष्णाग्री, तीक्ष्ण, खॉचाग्री, कुंठाग्र, दांतेदार, अर्ध-संयुक्तदली ।

चार उप-भूखंड से लाये गये भिन्न प्रकार के पौध के रासायणीक अंगुलीछाप परिणामो ने एच.पी. टी.एल.सी. प्लेट में ११ पट्टीयाँ दिखाई । फिर भी, पट्टीयों की पौध-प्रकार के प्रति विशिष्टता का पता नही लग पाया। हर एक घटक की सांद्रता, पौध प्रकारों में भिन्न थी ।

गुडूची

रा.औ.सु.पा.अ.के. में पौध-जाति का पुष्प-जीवविज्ञान के अतिरिक्त प्राप्य जनीन-द्रव्यों में नर एवं मादा पौधो में असमानता ढूँढने का अभ्यास किया गया । गुडूची के समूह में, पर्ण-प्रकार में बहुरुपीता बहुत ज्यादा सुस्पष्ट थी । पर्ण-आधार, हृदयाकार से उप-हृदयाकार व तीक्ष्ण हृदयाकार व छिन्नभ तक और पर्ण-टोच कुंठाग्र, तीक्ष्णाग्री व साग्रक तक भिन्न थे । सुक्ष्म बीजाणु मातृकोषो में न्यूनोक्तिक अभ्यास में न्यूनोत्किक चरण-१ में १३ ध्विसंयोजक पाए गये ।

पुष्प ऋतु-जैविकी विज्ञान का अब्यास दिसंबर से अप्रैल महीने तक किया गया और पाया गया कि दिसंबर में नर पूर्णपुष्पीय अवस्था में थे जबकि, इस महीने में मादा में पुष्प नहीं थे । इस जाति में परागोदभवन, २४ घंटो में बॅटी हुई अविरत प्रक्रिया है और महत्तम परागोदभवन दोपहर में था जैसे की १२.०० से ४.०० पी.एम. । इस जाति में एक अभ्यास में पाया गया कि, परागनयन वायु के द्वारा होता है और यह जाति वायु-परागित प्रकार की है । पुष्प-आगंतुक अफीड और काली चीटी (*डोलीकोडेरस*) पाए गये ।

भिन्न परगोदभवन समय पर इकट्ठा किए गये पराग में पराग स्फूरण का अब्यास किया गया । ६.०० पी.एम. पर खुलनेवाले पुष्प से महत्तम स्फूरण (६९.०९%) पाया गया ।

नर एवं मादा सूचकांको में से हर एक की पाँच पाँच पत्तीयाँ और तने के रासायणीक अंगुलीछाप

परिणामों ने पत्तीयोंमें सात और तने में नौ पट्टीयाँ दिखाई । जबकि, नर एवं मादा पौधो में पट्टीयों में स्पष्टरुप से कोई फर्क नहीं पाया गया ।

सुगंधीय पौधे

नींबुघास

हिसार में वंशक्रम एच.एल.-९ (११३६.०९ ग्राम), एच.एल.-५ (१०८५.२८ ग्राम) के बाद एच.एल.-१० बेस्ट चेक ओ.डी.-५८ के सापेक्ष महत्तम पौध उत्पाद (११७४.३१ ग्राम) दर्जित हुआ है । वंशक्रम सी.के.पी.-२५ में महत्तम तैली तत्व ०.८१% और तेल उत्पाद ६.५४ मी.ली. प्रति पौध दर्जित हुआ है ।

रा.औ.सु.अ.के. में नत्रजन देने से सूचकरूप से अधिक उत्पाद तथा उत्पाद संबंधी गुणों में वृद्धि पायी गयी । २०० कि.ग्रा. प्रति हेक्टर नत्रजन देने से सूचकरूप से पौध उत्पाद महत्तम (४२२३ कि.ग्रा. प्रति हेक्टर) पाया गया । एल.एस.-१ में महत्तम (४४.८१ टन प्रति हेक्टर) पौध और (२०५ कि.ग्रा. प्रति हेक्टर) तेल उत्पाद पाया गया ।

पामारोझा

हिसार में ताजा पौध उत्पाद प्रति पौध आर.एच.-०३-६७ (२.४८८ कि.ग्रा) में महत्तम और आर.एच.-०३-४७ (०.१५६ कि.ग्रा) में लघुत्तम था । ताजा वजन आधारित, तैल तत्व ०.२५ (आर.एच.-०३-३८) से लेकर ०.६०% (आर.एच.-०३-२९) में था । संगणित तेल उत्पाद प्रति पौध १.५ मी.ली. प्रति पौध (आर.एच.-०३-४७) से १०.७ मी.ली. प्रति पौध (आर.एच.-०३-६७) में था । जिरेनीओल तत्व ९.९०% से ८२.५% था । जिरेनायल एसीटेट तत्व १.१०% से १०.७६% था ।

रा.औ.सु.पा.अ.के. में महत्तम पौध उत्पाद (४७६९ कि.ग्रा. प्रति हेक्टर) और तेल उत्पाद (२४१.३९ कि.ग्रा. प्रति हेक्टर) १५० कि.ग्रा. नत्रजन प्रति हेक्टर से दर्जित हुआ । तेल में जिरेनीओल तत्व ७०.३३% से ७२.९५% के बीच और जिरेनायल एसीटेट भिन्न १५.७३ से १९.० तक था । गौबरखाद ०.५ और १० टन प्रति हेक्टर देने से सूचक रूप से विकास, उत्पाद और गुणवत्ता जैसे परिमाणोंपर कोई फर्क नहीं दिखा ।

सूचना प्रबंधन (एरीस)

एरीस-सेल ने 'इन्स्टीट्यूट इनवर्ड आउटवर्ड लेटर मोनीटरींग सीस्टम' (इओम्स) नामक सोफ्टवेयर, संसथा में आये हुए पत्रो को अन्य कर्मचारीयों को दर्ज किए जाने के बाद उनके द्वारा की गई प्रतिक्रिया की देखरेख के लिए विकसित किया । एरीस-सेल ने यह सोफ्टवेयर विकसित किया जिसके द्वारा पत्रों पर संपर्क बनाए रख सकते है और पत्रों की देखरेख आसानी से हो । इससे, जिस व्यक्ति को पत्र दर्जित किया गया है और उसके द्वारा निश्चित समयसीमा में पत्रों के प्रत्युत्तर के कार्य की अपेक्षा की जा सकती है ।

अन्य प्रवृत्तियाँ

संशोधन एवं विकास की गतिविधियों पर देखरेख के लिए केन्द्र द्वारा एस.आर.सी., आर.ए.सी. और आई.एम.सी की मिटींग की गई । वैज्ञानिक, प्रशासनिक एवं तकनीकी सभ्यों को उनकी कार्यशक्ति बढाने के लिए प्रशिक्षण हेतु भेजा गया । मलेशिया में एशिया पेसिफिक औषधीय पादप मिटींग मे भारत का प्रतिनिधित्व करने के लिए निदेशकश्री को भेजने के लिए रा.औ.सु.पा.अ.के. गौरवान्वित है । रा.औ.सु.पा.अ.के के परिवार ने हिन्दी सप्ताह और वार्षिक दिवस मनाया । रा.औ.सु.पा.अ. के एवं पान-परियोजना के कार्यकरों ने कई शोध पत्रिकाए प्रकाशित की ।

SUMMARY

National Research Centre for Medicinal and Aromatic Plants (NRCMAP) located at Anand and its out reach programme, All India Networking Research Project on Medicinal and Aromatic Plants are engaged in research on medicinal and aromatic plants under the ICAR system. Important research findings of 2004-05 are presented below species-wise:

Research Achievements

Aloe

The accession NMRM-2 was found to contain high Aloin A among all the existing accessions. Since multiplication rate under field condition was low, clonal propagation of this genotype was tried through micro-propagation at NRCMAP. Shoot bud explants raised *in vitro* was used to produce multiple shoots after surface sterilization. The result indicated that starting with a single shoot bud as explant, it was possible to obtain 28 shoot buds after 2 weeks of cultures on ½ MS basal medium supplemented with different concentrations of BA, IAA and sucrose.

Ashwagandha

At Hisar, total biomass yield per plant varied from 63.4 to 308.4 g. Genotype GP-27-Local recorded highest root yield (38.5 g plant^{-1}) followed by WS-218 (26.5 g plant^{-1}) and WS-90-125 (25.0 g plant^{-1}) whereas the check JA-20 yielded 15.0 g plant^{-1}. Fresh and dry root yields were recorded maximum 3542 and 828 kg ha^{-1}, respectively with a seed rate of 12 kg ha^{-1}.

At Mandsaur, a total of 62 lines of Ashwagandha were evaluated for fourteen different characters. Wide range of variability was observed among the lines. With regard to dry root yield, MWS-308, MWS-324 and JA-134 were superior. Similarly, seed yield ranged from 222 (MWS-333) to 694 kg ha^{-1} (MWS-308 and JA-134). Highest alkaloids content (0.68%) was in JA-134 followed by MWS-223 (0.6%). Highest root yield (642 kg ha^{-1}) was obtained from application of 5 tonnes ha^{-1} of vermicompost.

At Udaipur, the variety JA-20 was found to be superior over JA-134 in terms of root yield. The seed rate at 8 kg ha^{-1} produced significantly highest fresh (1290 kg ha^{-1}) and dry (465 kg ha^{-1}) root yield. Sowing on 1st September and harvesting on 1st April recorded significantly highest root yield (1625 kg ha^{-1}). Total alkaloid content also increased with the age of the crop under all the sowing dates

At Akola, highest root yield was recorded with the harvesting at 100% flowering stage (563 kg ha^{-1}). The yield of total alkaloids was significantly highest with 100% flowering stage (350 kg ha^{-1}).

Asalio

Nine germplasm lines of asalio, collected from farmers' field were tested for seed yield and its contributing characters. Highest seed yield was obtained in MLS-7 (2066 kg ha^{-1}) followed by MLS-1 (1823 kg ha^{-1}) and MLS-3 (1703 kg ha^{-1}) and were significantly superior to the other entries. Highest seed yield of 658 kg ha^{-1} was recorded with 0.6 IW:CPE, which was at par with 0.8 and 1.0 IW:CPE (609 and 602 kg ha^{-1}, respectively) at NRCMAP.

Asparagus

At Hisar, dry weight of fasciculated roots per plant ranged from 0.57 to 1.39 kg plant^{-1} and saponin content from 4.50 to 5.34 percent. Highest dry fasciculated root yield per plant was in HAR-7 (1.39 kg) followed by HAR-3 (1.23 kg), HAR-2 (0.998 kg) and HAR-6 (0.91 kg).). Interaction effects between date of sowing and seed rate revealed that 24th June sowing significantly recorded highest fresh fleshy root yield with seed rate of 6.0 kg ha^{-1} (88734 kg ha^{-1}). At Akola, maximum saponin was observed in oven dried sample in airtight container (4.76%) followed by sample processed under same method and kept in open container (4.62%), both being at par.

Chirayita

At Solan, extraction and estimation method of bitter compounds was standardised. Extraction was made from shade dried radicle leaves collected from the field grown plants.

Isabgol

At Hisar, the highest seed yield per plant was recorded in genotype EC-41181-37 (7.2 g) followed by P-96 (6.9 g), PB-10-4 (6.5 g), PB-31 (6.4 g), DM-7 (6.3 g), PS-19 (6.2 g) and P-79 (6.1 g), whereas the best check GI-1 recorded seed yield of 4.7 g plant^{-1}. At Mandsaur, swelling factor (ml g^{-1}) varied from 6.0 (SPS-19) to 9.6 (SLS-16) and days to 50 percent flowering ranged from 56 (SLS-01) to 69 days (SLS-63). Seed yield ranged from 297 kg ha^{-1} (SLS-65) to 1450 kg ha^{-1} (SLS-59). Sowing on 21st November produced significantly higher seed yield (834 kg ha^{-1}). Maximum seed yield was produced with three (689 kg ha^{-1}) and two (687 kg ha^{-1}) irrigations.

At Akola, sowing on 20th November produced significantly highest seed yield (3660 kg ha^{-1}). At Udaipur, application of three irrigations (at tiller initiation + full tiller + 75% flowering) produced highest seed (1468 kg ha^{-1}) and straw (3031 kg ha^{-1}) yields compared to others. Sprays of 0.4 ppm brassinosteroid yielded significantly highest seed (1189 kg ha^{-1}) and straw (2461 kg ha^{-1}) compared to 0.2 ppm (1023 kg ha^{-1} seed and 2323 kg ha^{-1} straw) and control (864 kg ha^{-1} seed and 2135 kg ha^{-1} straw).

At NRCMAP, two biodynamic dates (November 15 and 25) and four other dates (November 9, 12, 20 and 28) were considered to develop organic based agro technology. Results revealed that plant growth was not influenced by planting dates at 30, 60 and 90 days after sowing. Seed yield varied from 1353 to 1206 kg ha^{-1} in the earlier sowings and were at par. While sowing on November 28 produced significantly lowest (934 kg ha^{-1}) seed yield. Highest straw yield (10258 kg ha^{-1}) was recorded with November 9 sowing date. Biodynamic calendar dates did not show any significant effect on growth, physiology, disease development and yield. Spraying with herbal mixture and *panchagavya* did not influence the length of spike and number of empty spikes per plant. However, seed and straw yields and harvest index were significantly influenced by treatments. Though no definite trend could be found, pre-infection single (1270 kg ha^{-1}) or, double sprays of herbal mixture (1403 kg ha^{-1}) or, post-infection single spray of herbal mixture (1334 kg ha^{-1}) or, *panchagavya* (1294 kg ha^{-1}) enhanced the seed yield significantly over

control (1088 kg ha^{-1}). Application of FYM increased the nitrogen use efficiency with inorganic- and bio-fertiliser with the result N content increased from 2.10% to 2.14% in seed and from 0.67% to 0.71% in straw with FYM.

Kalmegh

Six accessions of *Andrographis* collected from different parts of India were evaluated at Anand center for quality yield. Significantly higher yield was obtained in accession number 3 (2844 kg ha^{-1}). However, no significant difference was found in the case of andrographoloide content among the accessions studied.

Forty-three accessions evaluated at NRCMAP based on plant height, number of branches, plant spread, herbage yield and andrographoloide content revealed that fresh and dry herbage yields were highest in IC 342136 (290.6 g plant $^{-1}$ and 99.16 g plant $^{-1)}$ and lowest in IC 111286 (120.8 g plant $^{-1}$ and 32.12 g plant $^{-1)}$. Andrographoloide content (%) in stem was highest in IC 260035 and IC 210635 (0.365) and lowest in IC 342141 (0.09). However, andrographoloide content in leaf was highest in IC 342141 (4.67%) and lowest in accession from Bhubneswar (1.281%).

Liquorice

At Hisar, fresh stolon yield was higher in the genotype HMK-6-2 (161.11 q ha^{-1}) followed by HMK-1-3 (136.11 q ha^{-1}), HMK-7-1 (125.00 q ha^{-1}), HMK-7-4 (111.11 q ha^{-1}), HMK-1-2 (108.33 q ha^{-1}) and HMK-7-5 (105.55 q ha^{-1}) against check HM-1 (94.44 q ha^{-1}).

Opium poppy

At Faizabad, one hundred and eighteen germplasms from different centres along with four checks were evaluated. Maximum latex yield was recorded for the genotype 1385 (42.70 kg ha^{-1}). Maximum seed yield was recorded for the genotype NOP 03-1 (958 kg ha^{-1}) and maximum husk yield was recorded for N.D-20 (833 kg ha^{-1}). At Mandsaur, latex yield (kg ha^{-1}) ranged from 11.91 (IC-19) to 77.45 kg (MOP-1069) and seed yield (kg ha^{-1}) ranged from 208 (IC-95) to 1249 kg (NBRI-5). Morphine percent ranged from 12.4 to 17.3 %, while thebain content was recorded low in MOP-1074), medium in MOP-575 and high in MOP-513. Highest latex yield was obtained with 75% of N supplementation through FYM and among the treatments receiving vermicompost, highest latex yield of 21.42 kg ha^{-1} was recorded from 75% N supplementation. Among the vermicompost applications, highest seed (659 kg ha^{-1}) and husk (517 kg ha^{-1}) yields were obtained from 100% organic source.

A total of 110 genotypes were screened under the field condition for resistance against downy mildew disease at Mandsaur and those were categorised into four groups. Since demands for non-morphine alkaloids like thebine and codine are increasing, an attempt was made at Mandsaur to characterise 50 lines according to their alkaloid contents. Some of the lines were found to contain high concentrations for more than one alkaloids. IC-114 and MOP-541 were having higher concentrations of all the three alkaloids.

Safed musli

At NRCMAP, fresh fasciculated root yield ranged from 5.77 g plant^{-1} in GUJ-1 to 23.77 g plant^{-1} in RAJ-11. Number of fleshy roots per plant was highest in GUJ-2 (20.43 g) and it was lowest in GUJ-1(4.30 g). Length of fleshy root ranged from 1.97 cm (GUJ-1) to 9.26 cm (MP-4). **Two safed musli lines (NRCCB-1 and NRCCB-2) developed from NRCMAP were registered by the National Germplasm Registration Committee as INGR No. 04113 and INGR No. 04114**. To maximise the shoot multiplication under tissue culture conditions the germinated shoot bud explants derived from stem disc was used for multiplication on basal half strength MS media supplemented with BA, Kinetin, NAA, IAA and Adenine sulphate. The medium with BA and adenine sulphate helped in the rapid multiplication of shoots. The rate of shoot multiplication was maximum on the medium containing BAP, adenine sulphate and NAA in different proportions. This treatment produced maximum (11.2) shoots per culture within 4 weeks

At Anand center, inflorescence was removed regularly from the plants. Removal of inflorescence (detopping) increased the vegetative growth, yield parameters and fleshy root yield. Fresh fleshy root yield recorded significant increase of 31.70% in the detopped plants over control. Fleshy root yield was 6764.56 kg ha^{-1} after detopping compared to 5136.19 kg ha^{-1}. Different plant populations significantly influenced the fresh fleshy root yield. Highest fleshy root yield (11855 kg ha^{-1}) was obtained from 10x10 cm spacing. Increase in fleshy root yield increased the total income, highest being Rs. 2265400 recorded from closest spacing and minimum (Rs.1343800) from 10x10 cm spacing. However, cost: benefit ratio was highest (1:6.16) with lowest plant population.

At Udaipur, significantly higher fresh root yield (6657 kg ha^{-1}) was obtained from the variety MCB-405 compared to MCB-412 (6064 kg ha^{-1}). Closest spacing produced significantly highest fleshy root yield (7743 kg ha^{-1}). Maximum fresh root yield was obtained by the variety MCB-405 (7952 kg ha^{-1}) planted at plant to plant distance of 10 cm. Similarly, significant highest dry root yield of 1590 kg ha^{-1} was recorded in variety MCB-405 with closest spacing. Among different planting methods tried, all the yield attributes and fresh fleshy root yield were recorded maximum in the ridge planting. Fresh fleshy root yield was highest (1645 kg ha^{-1}) in ridge planting method. Sapogenin content varied from 0.68 to 0.69% and did not vary significantly due to planting methods.

At Akola, quality of fleshy root powder, in terms of saponin content decreased with storage. Significantly lowest content was recorded after 12 months of storage (5.79%). Highest saponin was found in oven dried material kept in airtight container (6.13%).

At Mandsaur, to develop proper management of fleshy root rot disease, soil application of potash @ 60 kg ha^{-1} and *Trichoderma viridi* @ 5 kg ha^{-1} and/or, seed treatment with Bavistin @ 0.15% were either used single or in different combinations. Combined treatment of potash, Trichoderma and Bavistin produced significantly lowest fleshy root rot incidence (14.15%).

Sankhpushpi

At NRCMAP, study on variation in plant types, corolla type and petal colour,

reproductive biology including the breeding behaviour of the species was studied. In the population, three plant types were identified based on nature of inflorescence i.e., plants with either pedunculate (pedunculate type) or sessile inflorescence (sessile type) or plants with both pedunculate and sessile inflorescence (intermediate type). Polymorphism in terms of flower colour was also recorded. Three distinct colour types were recorded. Eight different types of corolla shape were observed in the population namely mucrunate, acute between, acute, retuse, obtuse, serrated, semi-gamopetalous

Chemical finger printing results showed 11 bands in HPTLC plates of different plant types collected from four subplots. However, band specificity to particular plant types was not detected. The concentration of individual constituents varied among the plant types.

Tinospora

At NRCMAP, besides floral biology of the species, a study was conducted to find out differences among the male and female plants of the species within the available germplasm. Polymorphism in leaf shape was very much pronounced in the population of Tinospora. Leaf base varied from cordate, subcordate or deeply cordate or truncate and leaf apex varied from obtuse, mucronulate or apiculate in the population. Meiotic study conducted in microspore mother cells, showed 13 bivalents at meiotic metaphase I.

Flowering phenology was studied from the month of December to April and it was found that males were in full bloom in December, however, females were not in flowering during this month. Anthesis in the species is a continuous process distributed in a period of 24 hours and maximum anthesis was in the afternoon i.e. 12.00 to 4.00 pm. The study indicated that pollen transfer in the species is through wind and the species is anemophilous type. Floral visitors identified were aphids and black ant (*Dolichoderus* spp.).

Pollen germination was studied in pollens collected at different anthesis time. Flowers opened at 6.00 pm gave maximum germination (69.09%).

Results of chemical fingerprinting of leaf and stem of five each of male and female accessions showed the presence of seven bands in leaf and nine bands in stem. However, no specific band differentiation could be observed in male and female plants**.**

Lemongrass

At Hisar, the genotype HL-10 recorded highest herb yield per plant (1174.31 g) followed by HL-9 (1136.09 g), HL-5 (1085.28 g) against best check OD-58 (1084.23 g). The genotype CKP-25 recorded highest oil content of 0.81% and oil yield of 6.54 ml plant^{-1}.

At NRCMAP, application of nitrogen significantly increased yield and yield attributing characters. Herbage yield was significantly maximum (4223 kg ha^{-1}) with application of 200 kg ha^{-1} of N. Herbage (44.81 tonnes ha^{-1}) and oil (205 kg ha^{-1}) yield were found to be highest in LS-1.

Palmarosa

At NRCMAP, the maximum herbage (4769 kg ha^{-1}) and oil yield (241.39 kg ha^{-1}) were recorded with 150 kg N ha^{-1}. The geraniol content in the oil ranged between 70.33-72.94% while geraniol acetate varied from 15.73-19.00. Application of FYM @ 0, 5 and 10 tonnes ha^{-1} did not show significant difference in respect of growth, yield and quality parameters

At Hisar, fresh herb yield per plant was highest in RH-03-67 (2.488 kg) and lowest in RH-03-47 (0.156 kg). Oil content on fresh weight basis (FWB) ranged from 0.25 (RH-03-38) to 0.60 percent (RH-03-29). Computed oil yield per plant ranged from 1.5 ml $plant^{-1}$ (RH-03-47) to 10.7 ml $plant^{-1}$ (RH-03-67). Geraniol content ranged from 9.90 percent to 82.50 percent. Geranyl acetate content ranged from 1.10 to 10.76 percent.

Information Management (ARIS)

ARIS cell has developed a software package entitled "Institute Inward Outward Letter Monitoring System" (IIOLMS) for monitoring letters received by the institute and thereafter marked to different employees for taking action. ARIS cell has developed this software by which track on letters can be kept and therefore monitoring can easily be done. It would rather precisely facilitate to keep track on persons to whom a letter is marked and thereby mandatory action from that person can be firmly expected within a time frame.

Other Activities

The Centre held meetings of SRC, RAC and IMC to monitor the research and developmental activities. Scientific, administrative and technical staff members were sent for training to increase their work efficiency. NRCMAP was proud to send the Director to represent India in the Asia Pacific Medicinal Plants Research Meeting in Malaysia. NRCMAP family also observed the Hindi week and Annual Day. The workers of medicinal and aromatic plants and betelvine published several research publications.

INTRODUCTION

Despite tremendous progress made in the medical science in the last few decades, in the field of organ transplantation and gene therapy for many deadly diseases, human suffering has not been reduced as dreamt. Rather number of cases of more deadly diseases such as AIDS, Cancer, heart disorders etc . is creating havoc. Therefore, interest in alternative medicine is markedly on the rise. As a result, holistic or integrated or alternative medicine has seized the attention of one and all. Thus there is tremendous need for a global movement for in-depth retrospection of various native health care traditions, which mainly uses medicinal plants. Not only that we need to care for conservation and revitalization of medicinal plants in nature for the post rarity of our future generations.

It is estimated that about 70,000 plant species starting from lichens to flowering tress have been used at one time or another for medicinal purposes. In India, medicinal plants have made a good contribution in the development of ancient Indian *Materia Medica*. One of the earliest treaties on Indian medicine, the *Charak Samhita* (1000 B.C.), records the use of over 340 drugs of plant origin. There is now urgent need to mainstream medicinal plants to provide primary health care on a sustainable basis to the poorest of the poor.

Most of the medicinal and aromatic plants are either collected from the wild or are harvested from introduced non-descript land races. Attention now must be given for breeding of superior quality and high yielding. Specificities of genotype environment interactions for obtaining optimal quality content of commercially important constituents also need to be focused. Attention must be paid to know the best time and stage of harvesting There is also need to use modern tools of experimentation to select, multiply and conserve the genotypes. Research efforts must be strengthened for understanding biosynthetic pathways of secondary metabolites.

In view of this changing scenario and in the light of urgency of meeting both domestic as well as export demands, there is need to improve cultivars, ecotypes, chemo-types, cultivation practices and post harvest technology so as to make research in medicinal and aromatic plants economically viable and socially acceptable. In this endeavour, National Research Centre for Medicinal and Aromatic Plants (NRCMAP) has taken steps to conduct research in all the above mentioned aspects. In this effort, its out reach programme on All India Networking Research Project on Medicinal and Aromatic Plants is also sharing its infrastruture and manpower towards the same goal. NRCMAP was established in 1992 to carry out research on medicinal and aromatic plants with following mandates and mandate crops.

Mandate

- Develop appropriate production, protection and processing technologies for important medicinal and aromatic plants through basic, strategic and applied research.
- Germplasm enhancement of various medicinal and aromatic plants.
- Production of parental lines and breeders' stock.
- Act as a National Repository for the genetic resources of some important medicinal and aromatic plants.

- Coordinate research under the All India Networking Project on Medicinal & Aromatic Plants and Betelvine.
- Act as Information Data Bank on medicinal and aromatic plants.
- Transfer of technologies developed by the NRCMAP to the farmers through cooperation with the developmental agencies.

Mandate Crops

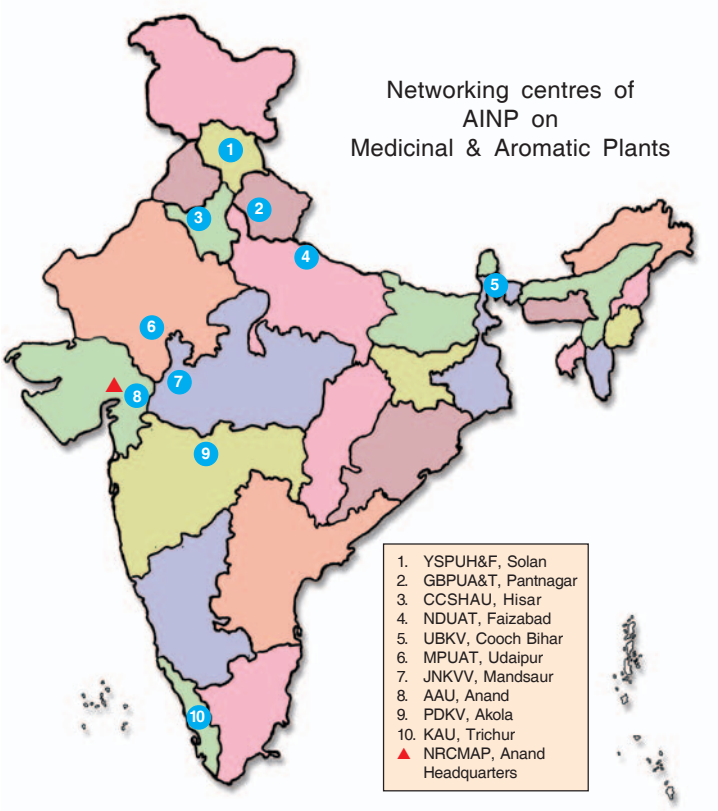
1. Isabgol (*Plantago ovata* Forsk.)
2. Senna (*Cassia angustifolia* Vahl.)
3. Ashwagandha (*Withania somnifera* Dunal)
4. Liquorice (*Glycyrrhiza glabra* Linn.)
5. Guggal (*Commiphora wightii* (Arn.) Bhandari)
6. Aloe (*Aloe barbadensis* Mill.)
7. Safed musli (*Chlorophytum borivilianum* Santapau & Fernandes.)
8. Lemongrass (*Cymbopogon flexuosus* Nees ex. Steud Wats.)
9. Palmarosa (*Cymbopogon martini* Stapf. Var. motia)

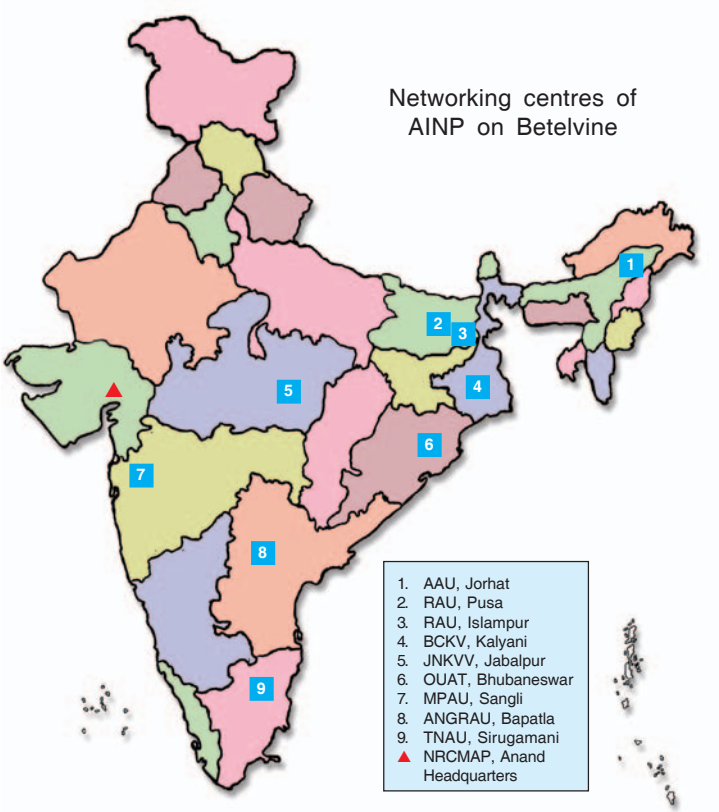
Objectives

1. To identify plants, which need attention of agricultural scientists and collect, maintain and evaluate the identified plants.
2. To carry out those basic researches on the chosen crops, which are useful to develop their agro-technology.
3. To coordinate the activities of the centres of the All India Networking Project on Medicinal & Aromatic Plants (AINPMAP) and Betelvine (AINPB) located in various agro-climate zones of India.
4. To provide planting material and technical know-how generated for further testing and refinement by the centres of the networking project and NRCMAP.
5. To develop partnership between this research centre and private sector, NGOs and Farmers' Association/Progressive farmers interested in promoting the use of herbal medicines.

Outreach Programmes

The head quarters of two All India Networking Projects such as All India Networking Project on Medicinal and Aromatic Plants (AINPMAP) and All India Networking Project on Betelvine (AINPB) are housed in the NRC. The Director is also responsible for coordination and monitoring of research work in these two projects as Project Co-ordinator in addition to his duties. There are ten centers in SAUs under AINPMAP and eight centers in SAUs participating under AINPB.


Networking centres of
AINP on
Medicinal & Aromatic Plants
1
2
3
4
5
6
7
8
9
10
1. YSPUH&F, Solan
2. GBPUA&T, Pantnagar
3. CCSHAU, Hisar
4. NDUAT, Faizabad
5. UBKV, Cooch Bihar
6. MPUAT, Udaipur
7. JNKVV, Mandsaur
8. AAU, Anand
9. PDKV, Akola
10. KAU, Trichur
▲ NRCMAP, Anand
Headquarters


Networking centres of
AINP on Betelvine
1
2
3
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6
7
8
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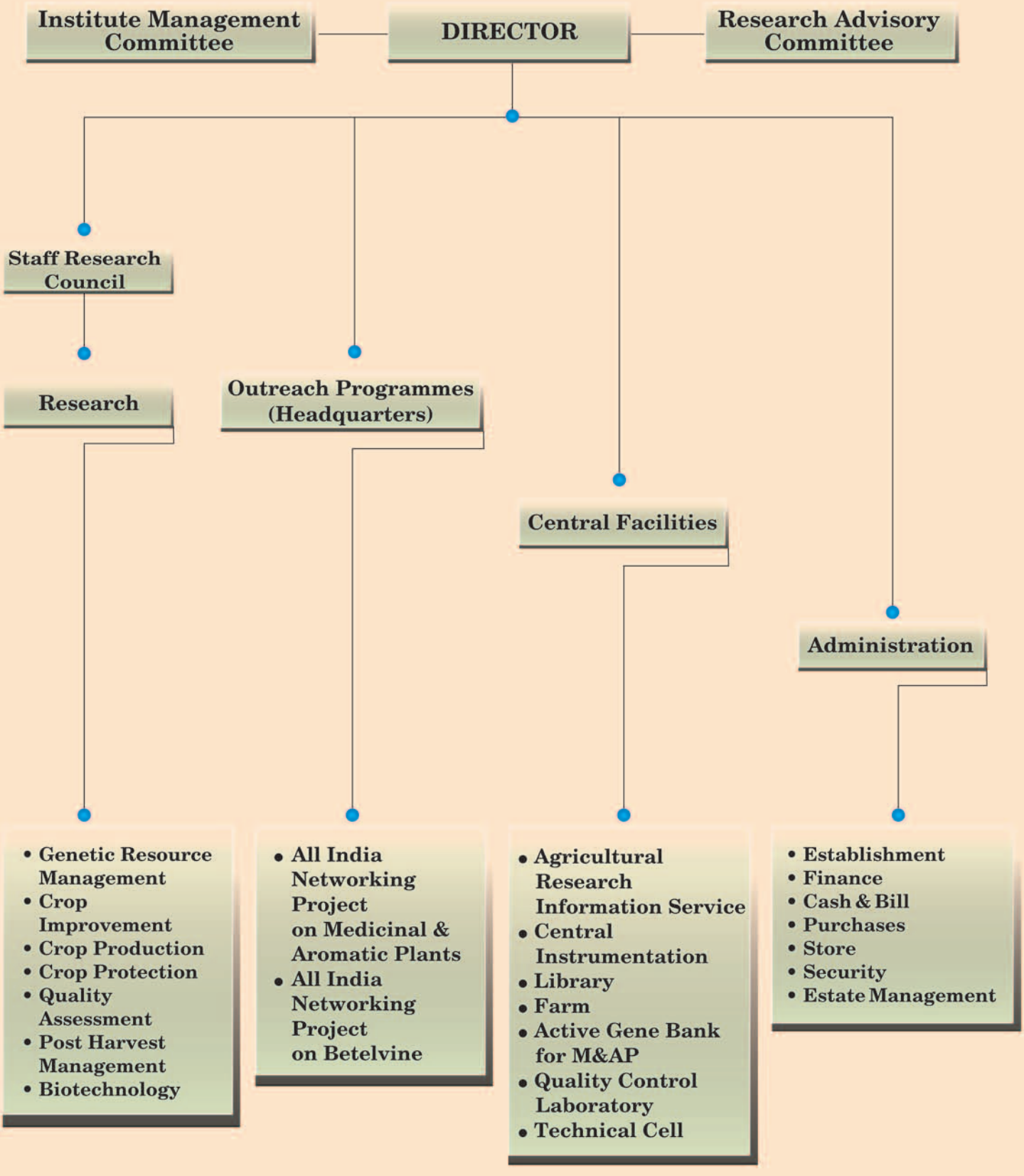
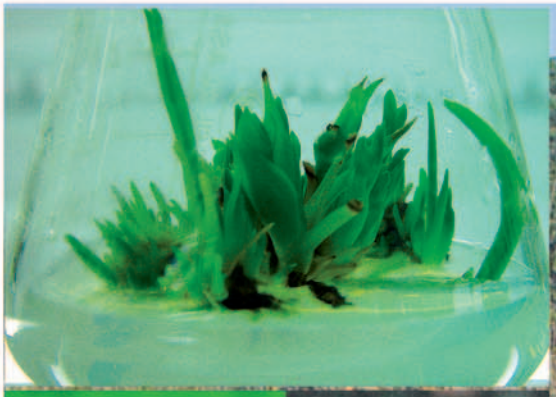
1. AAU, Jorhat
2. RAU, Pusa
3. RAU, Islampur
4. BCKV, Kalyani
5. JNKVV, Jabalpur
6. OUAT, Bhubaneswar
7. MPAU, Sangli
8. ANGRAU, Bapatla
9. TNAU, Sirugamani
▲ NRCMAP, Anand
Headquarters

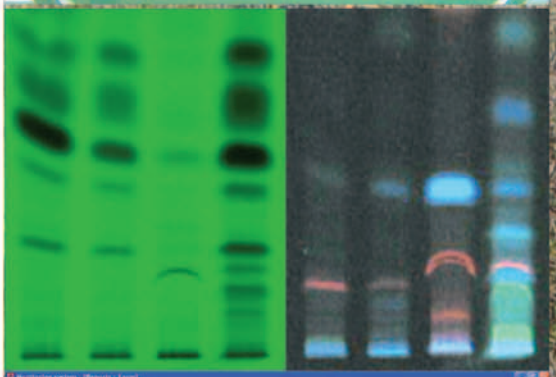
Organisational Structure

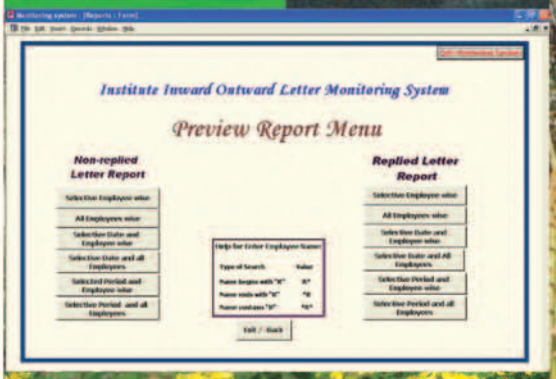


BUDGET PROFILE

Head	Expenditure (Rs.)
Non Plan Expenditure	**8365000**
Plan Expenditure	
NRCMAP	18500000
AINP on Medicinal & Aromatic Plants	15900000
AICRP on Betelvine	7100000
NATP (OM)	131000
Externally funded Projects	170000







RESEARCH ACHIEVEMENTS

MEDICINAL PLANTS

ALOE (*Aloe barbadensis*)

Aloe barbadensis is an important medicinal plant of Liliaceae family. It is a source of aloin and aloe gel besides many other compounds. It is used in preparation of a large number of herbal cosmetic products. Demand for such products has increased tremendously during the last few years. The crop is relatively new in cultivation. Large scale cultivation of the species has been initiated in some states. However, the main bottleneck faced by the farmers is lack of quality planting material, which is due to low multiplication rate.

Micro-propagation through shoot tip culture

Accession NMRM-2 was found to contain high Aloin A and gel content among all the existing accessions at NRCMAP. Since multiplication rate under field condition was low, clonal propagation of this genotype was tried through micro-propagation at NRCMAP. Shoot bud explants raised *in vitro* was used to produce multiple shoots after surface sterilization. All cultures were incubated at 25 ± 2°C under a light of 4500 lux from cool, white fluorescent lamps under 16 h photoperiod. Half strength MS media supplemented with different concentrations and combinations of cytokinin (BA or Kn) and auxin (IAA or NAA) were tested. The result indicated that starting with a single shoot bud as explant, it was possible to obtain 28 shoot buds after 2 weeks of cultures on ½ MS basal medium supplemented with different concentrations of BA, IAA and sucrose.

The decline in the micro-propagation efficiency is a common occurrence with several plant species. Therefore, plant regeneration efficiency under the developed protocol with repeated subculturing was done for twenty weeks. No reduction in culture was found up to 19 subcultures.

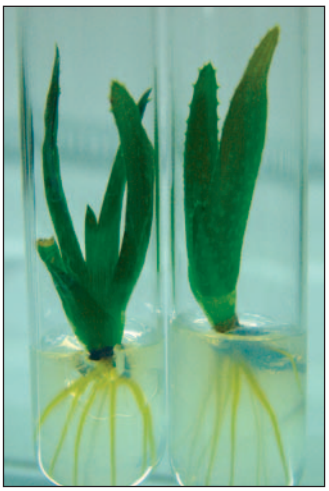


Fig. 1. Rooting in micropropagated Aloe at NRCMAP

After multiplication, micro-shoots (1-2 cm) were cultured on half strength MS basal salts supplemented with different concentrations of auxins and sucrose for induction of rooting. Percentage of rooting was estimated at 2 days intervals up to 15 days. Root formation was observed at higher concentration of IBA (0.50 mg l^{-1}), NAA (0.5 mg l^{-1}) and IAA (0.5 mg l^{-1}). However, IAA concentration was standardised to give 98.6% success rate (Fig. 1). Roots emerged in eight days were well developed into a root system within ten days of culture.

After fifteen days of rooting the plantlets were transferred into pots containing sterilised Soil:Sand:FYM (1:1:1) and kept in a room where the temperature,

RH and light were 25±2°C, 60-70%. and ca.4500 lux respectively, and covered with perforated poly bags. After 4 days the pots were shifted to a net house having 75% light intensity. After 15 days about 98 per cent plants survived when planted out side.

Micro-propagation through organogenesis

Small leaf bases were inoculated on ½ MS basal medium supplemented with different concentrations of cytokinin and auxin for induction of callus and incubated at 25 ± 2°C with 4500-lux illumination from cool, white fluorescent lamps having 16 h photoperiod. Callus formation was initiated at leaf base within 16-17 days of inoculation when cultured on ½ MS basal medium supplemented with different concentrations of BA in combination with 2-4-D. Callus growth was maximum in ½ MS basal medium supplemented with BA, 2-4-D along with ascorbic acid to prevent oxidation of phenol. After 3-4 weeks in the callusing phase, the calluses were subcultured in the media containing different concentrations of BA and IAA in combinations for shoot bud regeneration. The calluses differentiated into green nodular structures all over the callus mass after 3-4 weeks further developed into dark green shoot buds in ½ MS media supplemented with BA and IAA.

After regeneration, micro-shoots (1-2 cm) were cultured on ½ MS basal salts supplemented with different concentrations of auxins and sucrose for induction of rooting. All the cultures were incubated at 25±2°C under 16-h photoperiod. A high percentage (98.6%) of shoots rooted in the medium containing ½ MS supplemented with IAA.

ASHWAGANDHA (*Withania somnifera*)

It is an important medicinal plant cultivated in northwestern region of Madhya Pradesh. The plant belongs to the family Solanaceae. Mainly it is used for the preparation of vital ayurvedic tonics. Roots are the economic part used in many herbal preparations. The active ingredient of the plant is withaniols, somnifirin and several other alkaloids present in the roots. It is a late kharif crop. Sandy loam or light red soil with pH 7.5 to 8.0 with good drainage is suitable for its cultivation.

Evaluation of germplasm

Twenty eight genotypes were evaluated at Hisar for various morphological characters *viz.* plant height (cm), number of berries per plant, fresh weight of berries per plant (g), root length (cm), root diameter (mm), fresh root yield per plant (g) and total biomass yield per plant (g). Plant height ranged from 50.70 to 95.5 cm, number of berries per plant from 126.50 to 647.50, fresh weight of berries per plant from 10.4 to 65.0 g, root length from 11.7 to 28.4 cm, root diameter from 11.5 to 20.5 mm, fresh root yield per plant from 8.7 to 38.5 g. Total biomass yield per plant varied from 63.4 to 308.4

g. Genotype GP-27-Local recorded highest root yield (38.5 g plant^{-1}) followed by WS-218 (26.5 g plant^{-1}), WS-90-125 (25.0 g plant^{-1}) whereas the check JA-20 yielded 15.0 g plant^{-1}.

At Mandsaur, a total of 62 lines of ashwagandha were evaluated for fourteen different characters. Wide range of variability was observed among the lines. Plant height ranged from 16.2 cm (MWS 327) to 37.2 cm (MWS 207). The plants were classified on the basis of branching pattern *viz*. biparous (MWS-104, 106 and 114) and triparous (MWS-203, 303 and 312). Plants were either bushy or erect. Berry colour ranged from yellow (MWS 114, 223 and 212), orange (MWS 208, 221 and 227) and red. On the basis of maturity, plants were classified into three groups *viz*., early *i*.e., maturity period of 150-165 days (MWS-104, 210 and 227); medium *i*.e., maturity period of 165-180 days (MWS-135, 301 and 218) and late *i*.e., maturity period of 180-195 days (MWS-114, 214 and 302). Most of the lines were either in mid or in late maturing groups. Length of roots ranged from 10.2 cm (MWS-320) to 34.6 cm (MWS-221) and diameter from 4.0 (MWS-318) to 7.6 mm (MWS-218). Roots of MWS – 223, 224, 104, 106, 305, 318, 319 and JA-134 were of superior quality (quality grade-2 and 2.5). With regard to dry root yield, entries MWS-308, MWS-324 and JA-134 were superior. Similarly, seed yield ranged from 222 (MWS-333) to 694 kg ha^{-1} (MWS-308 and JA-134). Highest alkaloids content (0.68%) was in JA-134 followed by MWS-223 (0.6%).

Varietal trial

Ten promising lines of ashwagandha were evaluated against two checks *viz*. JA-20 and JA-134 at Mandsaur and significant difference was observed among the lines in dry root yield (Fig 2). Maximum dry root yield was recorded in MWS-131 (712 kg ha^{-1}) followed by MWS-211 (611 kg ha^{-1}), MWS-214 (597 kg ha^{-1}), MWS-119 (590 kg ha^{-1}) and MWS-100 (541 kg ha^{-1}). Dry root yield ranged from 476 kg to 712 kg ha^{-1}. No significant differences were there in seed among the lines. Root length ranged from 11.8 cm (MWS-132) to 27.6 cm (MWS-202). Root quality was highest in entry MWS-100, MWS-201 (2.0 grade) followed by MWS-131, MWS-132, MWS-213 and JA-134 (2.5 grade). Highest root diameter was in MWS-202 (7.0mm) followed by MWS-117 and MWS-213 and MWS-119 which were superior to the check JA-134 (5.4 mm). Alkaloid percent was maximum in the check (JA-134) i.e. 0.63 percent followed by MWS-100, JA-20 and MWS-202.

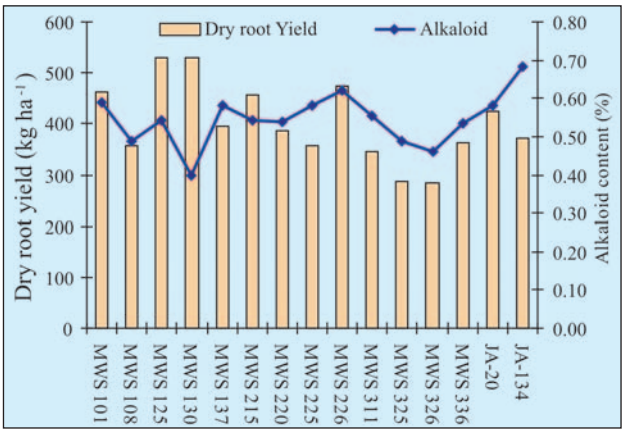


Fig. 2. : Varietal trial of Ashwagandha at Mandsaur

In another trial, thirteen promising entries of Ashwagandha were evaluated against checks JA-20 and JA-134. Dry root yield was significantly higher in MWS-125 and 130 (531 kg ha^{-1}) compared to the best check JA-20 (424 kg ha^{-1}). Entry MWS-101 (474 kg ha^{-1}) was superior to check JA-134 (372 kg ha^{-1}). Differences in seed yield were not significant among the entries. Only one entry exhibited quality root grade *viz*.

WS-101, which was chemically superior genotype and the entry MWS-101 was found superior genotype.

Effect of different seed rates on root yield

At Hisar, two released varieties (JA-20 and JA-134) were grown using four seed rates (6, 8, 10 and 12 kg ha^{-1}) to standardize the optimum seed rate. Among the varieties JA-134 (768 kg ha^{-1}) out yielded JA-20 (658 kg ha^{-1}) in terms of dry root yield. Plant height (48.1 cm), root diameter (1.73 cm), fresh and dry root weight (34.84 and 2.83 g $palnt^{-1}$) were also significantly superior in JA-134. In both the varieties plant height and root yield increased with the increase in seed rate. Seed rate of 12 kg ha^{-1} produced maximum plant height (51.7 cm) and maximum dry root yield (828 kg ha^{-1}). However, root diameter and root weight per plant decreased with higher seed rate. Maximum root diameter (1.72 cm) was found in seed rate of 6 kg ha^{-1} while thinnest (1.47 cm) root was produced with 12 kg ha^{-1} seed rate. Fresh and dry root yields were maximum (3542 and 828 kg ha^{-1}) with the seed rate of 12 kg ha^{-1}. However, these were at par with 10 kg ha^{-1} seed rate (3489 and 810 kg ha^{-1}).

At Udaipur, interestingly, the variety JA-20 was found to be superior over JA-134 in terms of root yield. Differences in plant height and number of branches per plant were non-significant. Two varieties differed significantly in relation to time taken for maturity. Variety JA-20 was early maturing type compared to JA-134. Maturity time was 180.19 days for JA-134 while it was 172.94 days for JA-20. Different seed rates did not produce any significant difference in maturity period. Significantly higher fresh root yield (1174 kg ha^{-1}) was recorded in the variety JA-20 compared to JA-134 (865 kg ha^{-1}). Increase in seed rate initially increased the root yield but later on decreased. The seed rate at 8 kg ha^{-1} produced significantly highest fresh (1290 kg ha^{-1}) and dry (465 kg ha^{-1}) root yields. It was observed that application of higher quantity of seed rate was supra optimal and minimum dry root yield (313 kg ha^{-1}) was obtained at highest seed rate tested (12 kg ha^{-1}). The interaction effect between variety and seed rate was found non-significant. Highest root-shoot ratio (2.25:26.96) was recorded with the application of 10 kg ha^{-1} seed in variety JA-20, while lowest root-shoot ratio (1.87:11.59) was observed in JA-134 with the seed rate of 6 kg ha^{-1}.

In a similar study, five different seed rates (6, 7, 8, 9, and 10 kg ha^{-1}) were tried to optimise the seed requirement at Akola. It was found that plant height increased with increase in seed rate. Tallest (46 cm) and smallest plants (36.45 cm) were observed in seed rates of 10 kg ha^{-1} and 6 kg ha^{-1}, respectively. However, number of branches per plant decreased with increase in seed rate. Highest root length (18.42 cm) was found in highest seed rate tested. However, thickness of root decreased in higher seed rates. Thickest root was obtained from seed rate of 6 kg ha^{-1} (0.72 cm) while lowest root girth was observed in 10 kg ha^{-1} seed rate (0.54 cm). Significantly maximum root yield (563 kg ha^{-1}) was obtained in 10 kg ha^{-1} seed rate. However, it was at par with 9 kg ha^{-1} seed application (524 kg ha^{-1}). Lowest root yield of 367 kg ha^{-1} was obtained from the seed rate of 4 kg ha^{-1}.

Effect of different levels of FYM on root yield

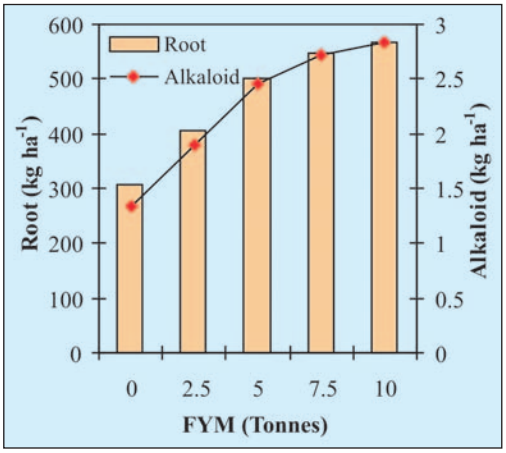


Fig. 3. Effect of different levels of FYM on root and alkaloid yield of Ashwagandha at Akola

Four different levels of FYM (2.5, 5, 7.5 and 10 tonnes ha^{-1}) along with control were applied to see the effect on root yield at Akola (Fig 3). Significant differences could be observed among the treatments in all growth and yield attributing parameters studied. Application of 10 tonnes FYM ha^{-1} produced the highest plant height (45.4 cm) and it was at par with that of 7.5 tonnes ha^{-1} (43.5 cm) and 10 tonnes ha^{-1} (43.2 cm). Highest number of branches per plant (5.4) was produced with 7.5 tonnes ha^{-1} of FYM. However, it was at par with all other treatments except control (3.82 $plant^{-1}$). Root length and root girth also increased with increase in dose of FYM. Highest root length (18.95 cm) and root girth (0.64 cm) were observed in 10 tonnes ha^{-1} of FYM. However, these were at par with the 7.5 tonnes ha^{-1} of FYM. Root yield increased with application of FYM and it was highest at 10 tonnes ha^{-1} (567 kg ha^{-1}). Root quality was also found to be better in the FYM treated plants. Highest alkaloid was obtained in 10 tonnes ha^{-1} (0.50%) and it was at par with all the treatments except that of control (0.44%). As root yield and root quality increased with FYM application, highest total alkaloid yield was obtained from 10 tonnes FYM ha^{-1} (283.3 kg ha^{-1}). However, it was at par with 7.5 tonnes FYM ha^{-1} (271.4 kg ha^{-1}) and 5 tonnes FYM ha^{-1} (246.3 kg ha^{-1}). Lowest alkaloid yield was obtained from control (132.9 kg ha^{-1}).

A similar experiment was conducted at Hisar using three levels of FYM doses (2.5, 5 and 7.5 tonnes ha^{-1}) along with control. Application of FYM significantly increased yield attributes and root yield compared to control. However, growth parameters did not differ significantly between 5 and 7.5 tonnes ha^{-1} of FYM. Highest dry root yield of 801 kg ha^{-1} was obtained from 7.5 tonnes FYM ha^{-1}, which was 44.6% increase over control (554 kg ha^{-1}). Similarly an increase of 24.5% and 38.9% was also recorded with the application of 2.5 and 5 tonnes FYM ha^{-1}, respectively in dry root yield over control.

Effect of age of harvesting on root yield and quality

An experiment was conducted at Akola to monitor the changes in root yield and quality with respect to age of crop. The crop was harvested at five different phenological stages viz. flowering initiation, 50% flowering, 100% flowering, berry ripening and physiological maturity. Root yield was significantly influenced by the harvesting time. Root yield first increased with delay in harvesting, but later it decreased when harvesting was delayed beyond 100% flowering. Highest root yield was recorded with the harvesting at 100% flowering stage (563 kg ha^{-1}). However, it was at par at berry ripening (547 kg ha^{-1}) and physiological maturity (541 kg ha^{-1}). The harvesting time also influenced the total alkaloids content and it was maximum at 100% flowering (0.620%) followed by 50% flowering (0.617%),

berry ripening (0.598%) and maturity (0.595%), all being at par. Significantly lowest alkaloid content was found in the root harvested at flower initiation stage (0.516%). The yield of total alkaloids was significantly highest with 100% flowering stage (350 kg ha^{-1}). However, it was at par at berry ripening (328.2 kg ha^{-1}) and maturity (322.2 kg ha^{-1}) stage.

At Hisar, the crop was harvested at 120, 150 and 180 days after sowing (DAS). Growth and root yield were significantly influenced by dates of harvesting. Significantly highest plant height (41.4 cm), number of primary (15.8) and secondary (19.0) branches per plant were observed from harvest at 180 DAS. Other root yield attributes significantly increased with delay in harvesting from 120 DAS to 180 DAS. Highest root length (20.1 cm), root diameter (1.64 cm), fresh root weight per plant (22.4 g) and dry root weight per plant (4.7g) were observed at 180 DAS. An increase of 32.1 and 46.2 % was found in dry root yield at 150 DAS (737 kg ha^{-1}) and 180 DAS (816 kg ha^{-1}), respectively compared to harvesting at 120 DAS (558 kg ha^{-1}). Fresh stem weight, root weight and dry stem weight also followed the similar trend.

Monitoring periodical changes in root yield and quality at different sowing dates

A field experiment was conducted at Udaipur to select an appropriate sowing date with respect to increase in alkaloid content and yield. The crop was sown at 15 days interval starting from 16th July up to 16th September. Plants from 0.5 m^2 area was harvested from each treatment at 15 days interval starting from 45 DAS till maturity. Dry root yield, root alkaloid content and alkaloid yield were recorded at each harvest.

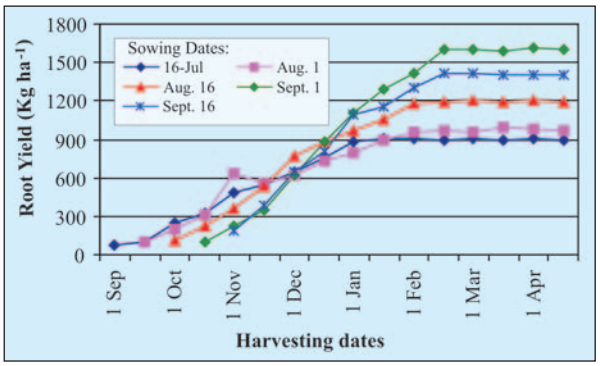


Fig. 4. Root yield of Ashwagandha at different dates of harvest at Udaipur

In early sowings (16th July and 1st August), dry root yield increased significantly up to 180 DAS. However, further increase in root yield was negligible after 180 DAS. In case of August 16 and September 1 sowings, this increase in root yield was recorded up to 165 days only. Further delay in sowing i.e. sowing on 16th September resulted in increase in root yield up to 150 days only. Sowing on 1st September and harvesting on 1st April recorded significantly highest root yield (1625 kg ha^{-1}) (Fig. 4) compared to other sowing and harvesting combinations. Total alkaloid content also increased with the age of the crop under all the sowing dates. In general, it was observed that this increase in total alkaloid content was from harvesting up to 180 DAS in case of early sowings (July 16 and August 1), while, in case of sowing on 16th August, 1st September and 16th September, the increase was recorded up to 150 DAS only. When different sowing dates were compared at same date of harvesting, no consistent trend was observed. However, sowing on 16th August in general resulted in significantly higher alkaloid content compared to other sowing dates, when harvesting was done after 1st January.

Effect of various plant growth regulators on root yield and quality

An experiment was conducted at Udaipur to increase the root yield by diverting the energy by means of suppressing the reproductive phase. Five different plant growth regulators (chlormequat 250 ppm, paclobutrazol 5 ppm, mepiquat chloride 1000 ppm, etheral 100 ppm and baylaton 16 ppm) were applied once at flower initiation or repeated again after 15 days of the first spray. Control along with manual removal of flower was also maintained for comparison. Root length was increased significantly by all the treatments as compared to control (15.03 cm), except that of etheral. Highest root length was observed with mepiquat (18.8 cm) applied twice. However, it was at par with application of chlormequat (18.6 cm). Differences in root diameter was non-significant however, it was highest with two sprays of mepiquat (5.6 cm). Dry root yield was significantly highest due to two sprays of chlormequat chloride (1348 kg ha^{-1}). It was followed by two sprays of mepiquat (1332 kg ha^{-1}), single application of chlormequat (1284 kg ha^{-1}) or, mepiquat (1262 kg ha^{-1}) and manual removal of flowers (1262 kg ha^{-1}). However, all these were at par statistically. Two sprays of mepiquat produced roots with significantly highest total alkaloid content (0.65%). Lowest alkaloid was recorded in control (0.34%).

Integrated nutrient management

At Mandsaur, different organic manures (FYM, poultry manure, goat manure and vermicompost) were applied in different doses as sole source of nutrients or as supplement to recommended dose of 20-60-40 kg ha^{-1} of NPK to see the effect on seed and root growth. Highest root yield (642 kg ha^{-1}) was obtained from application of 5 tonnes ha^{-1} of vermicompost. Application of poultry manure at 5 tonnes ha^{-1} along with 50% of recommended fertiliser dose produced 583 kg ha^{-1} dry root yield, which was at par with the best treatment. Minimum root yield (467 kg ha^{-1}) was obtained from control. Interestingly, this was at par with the yield obtained from treatments like recommended dose of fertiliser, 5 tonnes ha^{-1} vermicompost + 50% of recommended fertiliser and mixture of 5 tonnes ha^{-1} vermicompost + 5 tonnes ha^{-1} FYM. However, highest seed yield was recorded from 5 tonnes ha^{-1} goat manure (566 kg ha^{-1}). This was at par with 5 tonnes ha^{-1} vermicompost (528 kg ha^{-1}), 5 tonnes ha^{-1} poultry manure (521 kg ha^{-1}) and 5 tonnes ha^{-1} FYM (517 kg ha^{-1}). Significantly minimum seed yield was obtained from control (316 kg ha^{-1}).

ASALIO (*Lepidium sativum*)

Asalio belongs to the family Cruciferae and is a winter annual crop. The demand of this crop is increasing as a low water requiring medicinal herb. The crop is traditionally cultivated in small areas in the drier tracts of Gujarat, Rajasthan and Madhya Pradesh. Under present situation, in the light of its recent demand, development of the agro-technology along with enrichment of germplasm holding, etc. are important research areas.

Evaluation of germplasm

Nine germplasm lines of asalio, collected from farmers' field of Mandsaur, Neemuch and Ratlam districts were tested for seed yield and its contributing characters. Highest seed yield was in MLS-7 (2066 kg ha^{-1}) followed by MLS-1 (1823 kg ha^{-1}) and MLS-3 (1703 kg ha^{-1}) and were significantly superior to the other entries**.** The plant height ranged from 73.0 cm (MLS-5) to 111 cm (MLS-2) and number of branches ranged from 19.0 to 54.8. Maximum seed weight (1000 number) was recorded in entry MLS-3 and MLS-4 (9.45 g).

Development of irrigation schedule based on IW: CPE ratio

Irrigation was scheduled at four IW:CPE ratios (0.4, 0.6, 0.8 and 1.0) at NRCMAP. Plant height was significantly influenced by irrigation schedules at 30, 60 and 90 days after sowing. However, at 60 and 90 days after sowing, plant height was maximum with 0.6 IW:CPE (64.24 and 70.00 cm, respectively) and was at par with 0.8 and 1.0 IW:CPE. Number of branches was more with 0.8 IW:CPE (10.84 $plant^{-1}$) and was at par with 0.6 and 1.0 IW:CPE. Besides, different physiological parameters such as chlorophyll 'a', 'b' and total chlorophyll, photosynthesis rate, stomatal conductance, rate of respiration and transpiration, leaf area index and leaf area were recorded at 45 – 50 days after sowing. Among physiological parameters, chlorophyll 'a' and total chlorophyll, rate of photosynthesis were significantly influenced by IW:CPE ratio and their values ranged from 0.60 – 1.06 mg g^{-1}, 0.87 – 1.38 mg g^{-1} and 10.17 – 14.36 µmol $m^{-2}s^{-1}$, respectively. Moisture content of shoot at 75 DAS was significantly higher in 0.6, 0.8 and 1.0 IW:CPE compared to 0.4 IW:CPE (72.22%). Length of the taproot was also significantly maximum with 1.0 IW:CPE (16.52 cm). However, highest seed yield (658 kg ha^{-1}) was recorded with 0.6 IW:CPE, which was at par with 0.8 and 1.0 IW:CPE (609 and 602 kg ha^{-1}, respectively).

ASPARAGUS (*Asparagus racemosus*)

The plant belongs to the family Liliaceae and mainly propagated by seeds. It is a perennial crop. The fasciculated roots are medicinally important. Saponins are the active ingredient of the crop. Dry powder of the root is used for the preparation of many ayurvedic vital tonics. The crop is cultivated in lateritic, red loamy soils with adequate drainage and its cultivation is spread through out India, however, in limited scale.

Evaluation of germplasm

Eight genotypes viz. HAR-1, HAR-2, HAR-3, HAR-4, HAR-5, HAR-6, HAR-7 and HAR-8 were evaluated for dry weight and saponin content at Hisar. Dry weight of fasciculated roots per plant ranged from 0.57 to 1.39 kg $plant^{-1}$ and saponin content from 4.50 percent to 5.34 percent. Highest dry fasciculated root yield per plant was in HAR-7 (1.39 kg) followed by HAR-3 (1.23 kg), HAR-2 (0.998 kg) and HAR-6 (0.91 kg). On the basis of dry weight and saponin content genotype HAR-7 was found best.

Post harvest deterioration of quality of root powder

At Akola, post harvest deterioration in quality of fleshy root powder was monitored for one year. Fleshy roots harvested in the month of March were cleaned and dried by two methods viz. sun drying for three days or, oven drying at 60° C for 24 hours. The roots were then powdered and stored either in open container or, airtight container. The samples were taken for estimation at two months interval starting from May to March of following year. Moisture content of the root powder was influenced by the ambient humidity. However, effect of duration of storage on moisture content was nonsignificant. During the period of one year storage, saponin content of root powder gradually and significantly deteriorated. After two months of storage the saponin content was 5.12%, then reducing to 3.92% at the end of the year. Different drying and storage methods had significant effect on moisture content of the root powder. It was minimum when roots were dried in oven and kept in airtight container (8.33%) and it was at par with samples kept in open container (8.73%) dried under same method. Highest moisture content was recorded in the sample dried under sun and kept in open container (10.69%). Reverse trend was observed in case of saponin content of the sample. Maximum saponin was observed in oven dried sample in airtight container (4.76%) followed by sample processed under same method and kept in open container (4.62%), both being at par. Significantly poor quality, in terms of saponin content, was observed in sun dried material kept in open container (4.40%). Interaction effect between storage methods and period of storage was nonsignificant.

Effect of planting time and seed rate on yield and saponin content

Experiment was carried out to find out best sowing time and seed rate at Hisar taking three seed rates (4, 6 and 8 kg ha^{-1}) and three sowing dates (24th June, 16th July and 15th August). Plant population decreased significantly with delay in sowing from June 24 to August 15. Maximum plant population was observed when sowing was done on 24th June (248 lakhs ha^{-1}) while minimum on 15th August sowing (101 lakhs ha^{-1}). Growth parameters studied were also affected by delay in sowing. Above ground biomass (14530 kg ha^{-1}), number of fleshy roots per plant (206.7), root length (33.3 cm) and root girth (1.34 cm) were significantly highest from sowing on 24th June. Fresh fleshy root yield was also significantly highest (81455 kg ha^{-1}) in early sowing, which decreased to 64506 and 28395 kg ha^{-1} in two later dates of sowing (Fig. 5). Plant population, above ground green biomass and fresh fleshy root yield were significantly increased with the increment in seed rate whereas reverse trend was observed in case of number of fleshy root per plant, root length and root girth. Plant

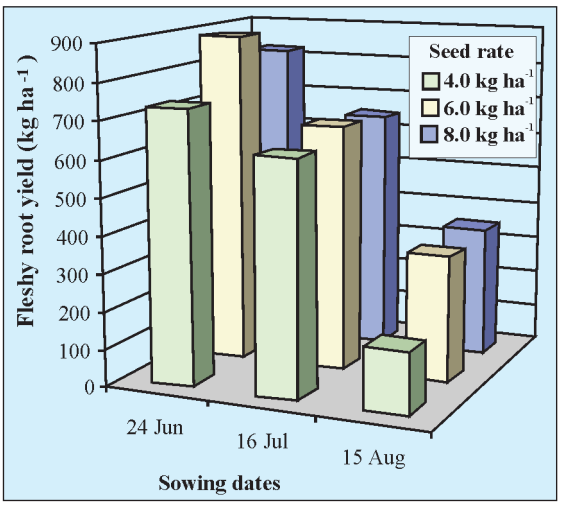


Fig. 5. Fresh fleshy root yield of asparagus under the influence of planting date and seed rate at Hisar

population increased from 147 to 231 lakhs ha^{-1} from 4 to 8 kg ha^{-1} seed rates, respectively. Lowest seed arte produced significantly highest number of fleshy root per plant (203.7), maximum root length (32.5 cm) and girth (1.28 cm). Fresh fleshy root yield was significantly highest in 6 kg ha^{-1} seed rate (62885 kg ha^{-1}) and it was at par with the seed rate of 8 kg ha^{-1} (60802 kg ha^{-1}). Interaction effects between date of sowing and seed rate revealed that 24th June sowing significantly recorded highest fresh fleshy root yield with seed rate of 6.0 kg ha^{-1} (88734 kg ha^{-1}) compared to other seed rates. In case of July sowing, fresh fleshy root yield was at par in all seed rates while in August sowing, maximum seed rate produced highest fleshy root yield (35184 kg ha^{-1}).

CHIRAYITA (*Swertia chirayita*)

Chirayita is a member of the family Gentianaceae. Among the different Swertia species, *Swertia chirayita* is commonly used for drug. The drug (chiretta) is obtained from the dried plants and is used against chronic fever, anaemia, bronchial asthma, and as a bitter tonic. *Swertia* grows well in the moist temperate Himalayas from Kashmir to Bhutan and in the Khasi hills in Meghalaya.

Extraction and estimation method for bitter compounds

At Solan, extraction and estimation method of bitter compounds was standardised. Extraction was made from shade dried radicle leaves collected from the field grown plants. The dried leaves were finely powdered and freed from less polar non-bitter compounds by refluxing with petroleum ether at 40-60^{o} C for 2 hrs. The contents were then filtered and residue was re-extracted by refluxing with petroleum ether. All the petroleum ether extracts were combined and then petroleum ether was distilled off. The residue thus obtained was found non-bitter and moved to the top of silica gel coated TLC plate using lower layer of chloroform: methanol: water (65:20:10) as the mobile phase.

The petroleum ether extracted leaf biomass was then refluxed with methanol (3 h) on boiling water and the contents were filtered. The residue was then repeatedly extracted with methanol through reflux (5 times) till the extract was found fairly bitter. All the methanol extracts were combined and methanol was then distilled off on a boiling water bath. The residue thus obtained was dissolved in methanol (200ml) and the contents were kept in the refrigerator overnight. The separated out solid mass was filtered and repeatedly washed with methanol. All the washings were combined with the main filtrate. The residue tasted as non-bitter whereas the filtrate was found bitter in taste. The filtrate was run on silica gel-G coated glass TLC plates using lower layer of Chloroform: Methanol : Water (65:20:10) as the solvent system. The developed TLC plate on being tasted at different zones showed two bitter compounds at Rf values between 0.40 and 0.60. The TLC plate on being sprayed with fast red B salt gave red spot for amarogentin. The mixture is being attempted for separation of individual bitter compounds through column chromatography over silica gel.

GUGGAL (*Commiphora wightii*)

The plant is a shrub, endemic to drier tract of Rajasthan and Gujarat. It belongs to the family Burseraceae and is not under commercial cultivation. The oleo-gum-resin obtained by tapping the plant is highly priced for its two major sterols *viz*. gugglusterone-Z and gugglusterone-E and is used as an indigenous drug against rheumatism, arthritis, etc. However, the plant generally dies after tapping and because of this reason and due to other disturbances, the natural habitat of this plant is shrinking. Distribution of the plant under natural habitat is dwindling and it is enlisted in the endangered category in the Red Data Book.

Selection of gum inducers

At Anand, guggal plants (seven plants per treatment) were tapped with natural gum solution, suspension of bacterium isolated from natural gum and preparation of *Botryodiplodia* isolate. Control plants were tapped with water. Gum yield was recorded after tapping. All the plants tapped with natural gum solution produced gum. However, gum yield varied from 5 to 55 g plant^{-1}. Tapping with *Botryodiplodia* resulted in gum exudation from 71.43% plants and gum yield varied from 2 to 5 g plant^{-1}. In case of tapping with bacterial suspension, only one plant out of seven produced gum with the yield of 5 g plant^{-1}. However, none of the control plants produced gum.

Estimation of guggulsterone-Z

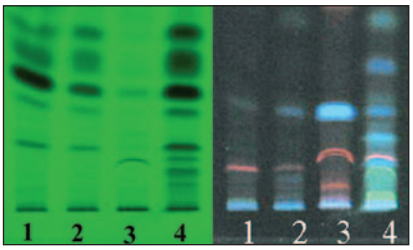


Fig. 6. Chemical fingerprint of Guggal plant parts (1 Fruit, 2 Wood, 3 Leaf, 4 Bark) at NRCMAP

At NRCMAP, chemical fingerprinting of different plant parts viz. fruit, wood, leaf and bark was done using HPTLC. Maximum eight major bands were noted from bark sample, which indicated that maximum chemical constituents were present in bark (Fig. 6). The protocol for guggulsterone-z estimation through HPLC was also standardised using solvent extraction of different plant parts. The standard was run in different known concentrations and it was found that retention time of guggulsterone-Z was at 22 minutes. Guggulsterone-Z in bark samples of primary, secondary and tertiary branches was then estimated by calculating the peak area of sample and guggulsterone -Z standard. Primary bark showed maximum amount of guggulsterone -Z content (121.33 μg g^{-1}) as compared to secondary (61.58 μg g^{-1}) and tertiary (68.98 μg g^{-1}) bark.

Guggulsterone-Z is a main constituent of guggalipid. Comparison of peaks area of ten male and ten female bark with standard through HPTLC analysis showed that female had (92.02±10.28 μg g^{-1} bark) more amount of guggalosterone-Z than male (46.98± 8.62 μg g^{-1} bark).

Hypericum *(Hypericum perforatum)*

The plant is a rhizomatous perennial herb cultivated for its essential oil. It belongs to the family Hypericaceae. It is grown in comparatively cooler climate. *Hypericum* possesses astringent, expectorant and diuretic properties and is used in pulmonary and urinary troubles, diarrhoea, hysteria and nervous depression, haemoptysis and other haemorrhages and jaundice.

Studies on variability

At Solan, seedlings of six accessions of *Hypericum perforatum*, collected from different regions of Himachal Pradesh were planted to study the variability in terms of number and size of glands on petals and leaves and also based on hypericin content in different plant types on the basis of gland size and density. Flowering had commenced from the month of May. These populations and also the earlier sown plants were monitored for morphological variations, based on leaf size/shape and gland density on petals/leaves. Two morphotypes based on leaf size were identified.

Extraction and estimation method for hypericin

Extraction and spectrophotometric estimation method of hypericin was standardised at Solan. The plants were collected for extraction at flowering stage. The aerial biomass was shade dried and ground into fine powder. The dried ground mass was soxhlet extracted with benzene on a boiling water bath until green pigment ceased extracting (5-8 hours). The material in thimble was then dried and re-extracted with 95% ethyl alcohol on a boiling water bath. Extraction continued until red coloured hypericin ceased extracting (6-10 hours). The hypericin concentration was estimated on spectronic 20 D^+ by recording absorbance at 592nm.

ISABGOL (*Plantago ovata*)

It is a member of Plantaginaceae family and traditionally grown in parts of Gujarat and Rajasthan. India is the sole exporter of Isabgol husk in the international market. Seed coat that is known under the trade name 'husk' is medicinally important. Mucilaginous layer of outer seed coat (Isabgol husk) is useful against constipation and gastrointestinal irritation. The swelling property of the mucilaginous polysaccharide of husk is responsible for the medicinal property. It is a rabi crop, which requires cool and dry climate in its growing season. Increasing seed yield with genetic manipulation or through better crop management, downy mildew disease management, etc. are important research areas in this crop.

Evaluation of germplasm

At Hisar, seventy eight germplasm lines were evaluated based on different characters *viz*. plant height (cm), branches per plant, spikelet length (cm), spikes per plant and seed yield per plant (g). Wide range of variability was recorded for plant height (27.5-46.6 cm), branches per plant (3.5- 11.9), spikes per plant (28.5- 94.8), spikelet length (2.4- 6.4 cm) and seed yield per plant (2.2- 7.2 g). The highest seed yield per plant was in genotype EC-41181-37 (7.2 g) followed by P-96 (6.9 g), PB-10-4 (6.5 g), PB-31 (6.4 g), DM-7 (6.3 g), PS-19 (6.2 g) and P-79 (6.1 g), whereas the best check GI-1 recorded seed yield of 4.7 g plant^{-1}.

At Mandsaur, a total of 80 lines of Isabgol were evaluated for eight characters. A wide range of variability was observed among the lines. Plant height ranged from 26.4 cm (MIB-1) to 40.0 cm (SLS-16). Number of spikes per plant ranged from 7.2 (SPS-12) to 31.6 (GI-2) and number of spikes per plant ranged from 3.4 cm (SLS-66) to 6.6 cm (SPS-7). Swelling factor (ml g^{-1}) varied from 6.0 (SPS-19) to 9.6 (SLS-16) and days to 50 percent flowering ranged from 56 (SLS-01) to 69 days (SLS-63). Seed yield ranged from 297 kg ha^{-1} (SLS-65) to 1450 kg ha^{-1} (SLS-59).

Effect of sowing time and seed rates on yield

An experiment was conducted at Akola where isabgol was newly introduced crop to find out suitable sowing time and seed rate for maximum yield. Five dates of sowing (at 10 days interval starting from 20th October to 30th November) and three seed rates (3kg, 4kg and 5kg ha^{-1}) were tried. Seed yield was significantly influenced by different sowing dates. Sowing on 20th November produced significantly highest seed yield (3660 kg ha^{-1}). However, it was at par with 10th November sowing (3450 kg ha^{-1}). Different seed rates did not have any significant effect on seed yield. Interaction effect was also non-significant. Monetary returns were also significantly highest with 20th November sowing. Gross monetary return (GMR) and net monetary return (NMR) were Rs. 14655 and Rs. 7665 ha^{-1}, respectively in this treatment. However, these were at par with 10th November sowing (GMR Rs. 13814 and NMR Rs. 6824 ha^{-1}).

Studies on irrigation management at varying levels of brassinosteroid

Since, isabgol is a crop of drier region, an experiment was conducted at Udaipur with an aim to develop appropriate irrigation schedule for this crop along with the application of brassinosteroid. One, two or, three times irrigation was applied during the crop growth apart from one irrigation after sowing. Each time 5 cm of irrigation was applied. Irrigation was scheduled at three different phenological stages of the crop growth (branching initiation, full branching and 75% flowering) in different combinations. Two doses of brassionosteroid (0.2 and 0.4 ppm) along with control (water) were sprayed at flower initiation stage and 20 days after the first spray.

Application of three irrigations (at branch initiation + full branching + 75% flowering) produced highest seed (1468 kg ha^{-1}) and straw (3031 kg ha^{-1}) yields compared to others (Fig. 7). Among the treatments receiving two irrigations, seed yields varied from 1183 to 1091 kg ha^{-1}. However, straw yield in this group was highest (2555 kg ha^{-1}) when irrigations were applied at full branching +

75% flowering. Application of single irrigation produced seed yields between 868 to 696 kg ha^{-1}. Among these, application of irrigation at full branching (868 kg ha^{-1}) and 75% flowering (737 kg ha^{-1}) were at par. In terms of straw yields these treatments yielded 2032 and 2025 kg ha^{-1}, respectively. Result at branching initiation (1762 kg ha^{-1}) stage exhibited poorest performance.

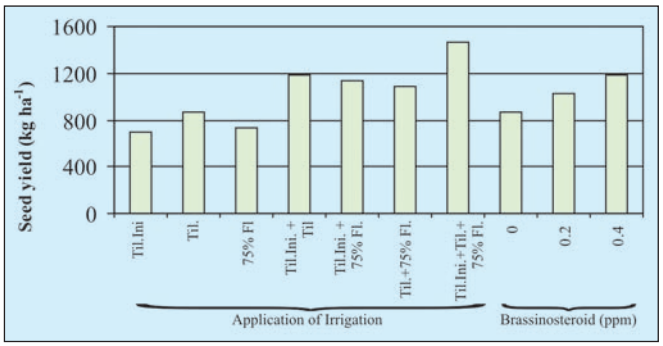


Fig. 7. Seed yield of Isabgol under the influence of irrigation and brassinosteroid at Udaipur

Sprays of 0.4 ppm brassinosteroid yielded significantly highest seed (1189 kg ha^{-1}) and straw (2461 kg ha^{-1}) compared to 0.2 ppm (1023 kg ha^{-1} seed and 2323 kg ha^{-1} straw) and control (864 kg ha^{-1} seed and 2135 kg ha^{-1} straw) (Fig 7). Application of 0.2 ppm of brassinosteroid also exhibited significant differences in yields over control.

Swelling factor and husk recovery of seeds were not influenced due to irrigation schedules and brassionosteroid sprays. However, husk yield (448.1 kg ha^{-1}) was significantly highest under three irrigations compared to rest of the schedules. Similarly, spray of 0.4 ppm brassionosteroid resulted in significantly highest husk yield (362.5 kg ha^{-1}) compared to 0.2 ppm and control.

Influence of bio-dynamic sowing dates on growth, physiology, downy mildew development and yield

With an aim to develop organic based agro technology, different biodynamic dates along with other dates were tried for sowing at NRCMAP. Two biodynamic dates (November 15 and 25) and four other dates (November 9, 12, 20 and 28) were considered for this purpose. Results revealed that plant growth was not influenced by planting dates at 30, 60 and 90 days after sowing. However, number of total and effective spikes per plant were higher in the early sown crop highest being at November 20 sowing (26.05 and 21.51). Besides growth parameters, some physiological parameters such as leaf area, leaf area index, chlorophyll content, rate of photosynthesis and respiration, stomatal conductance were also recorded at 55, 70 and 85 DAS. Irrespective of the treatments, leaf area, rate of photosynthesis, respiration and stomatal conductance were increased gradually from 55 DAS to 85 DAS but total chlorophyll content was in reverse order. Leaf area was highest in 20 November sown crop (15.10 cm^2 at 70 DAS). However, it was at par with all the earlier sown crop. Similar trend was observed in case of chlorophyll content, highest being 1.21 mg g $tissue^{-1}$ at 70 DAS. Photosynthetic rate at 70 DAS was at par in the crop sown up to November 25. However, it was significantly lowest in November 28 sown crop (17.80 CO_2 $\mu molm^{-2}$ s^{-1}). At 70 DAS, respiration rate was maximum in the last sown crop (5.04 CO_2 $\mu molm^{-2}$ s^{-1}). This was at par with November 25 sowing. With respect to disease severity, it was found to be maximum at 70 DAS in November 15th sowing. However, difference between the treatments in terms of PDI was non-significant. Seed yield varied from 1353 to 1206 kg ha^{-1} in the earlier sowings and were at par. While

sowing on November 28 produced significantly lowest (934 kg ha^{-1}) seed yield. Highest straw yield (10258 kg ha^{-1}) was recorded with November 9 sowing date. Hence, biodynamic calendar dates did not show any significant effect on growth, physiology, disease development and yield.

Effect of liquid manures on downy mildew development

The response of different liquid manures (Herbal mixture and *Panchgavya*) was tested at NRCMAP. The treatments were applied as sprays once or twice as pre-infection (25 and 40 DAS) or post-infection (7 and 21 days after infection). Downy mildew severity (PDI) of isabgol was recorded at the initiation of the disease spread (40-50 DAS) and at highest disease severity (70-80 DAS). Difference between different treatments in terms of PDI was non significant at disease initiation and at highest disease severity. Growth parameters were also monitored. Irrespective of treatments, plant height, number of leaf and branches per plant and shoot dry biomass increased gradually from 45 DAS–105 DAS. Number of branches and number of leaf per plant and length and width of leaf were not influenced by treatments. However, plant height and shoot biomass production were significantly influenced by various treatments at 75 and 105 DAS. Physiological parameters such as leaf area, chlorophyll content (Chlorophyll 'b' and total chlorophyll), rate of photosynthesis and respiration recorded at 55, 70 and 85 days after sowing were significantly influenced by application of liquid manures. No definite trend could be observed in case of leaf area and chlorophyll content while difference in stomatal conductance was non-significant. However, in case of herbal mixture rate of photosynthesis was higher (maximum 22.84 $\mu molm^{-2}s^{-1}$) and rate of respiration was lower (minimum 2.84 µmol CO_2 released $m^{-2}s^{-1}$). Spraying with herbal mixture and *panchagavya* did not influence the length of spike and number of empty spikes per plant. However, seed and straw yields and harvest index were significantly influenced by treatments. Though no definite trend could be found, pre-infection single (1270 kg ha^{-1}) or, double sprays of herbal mixture (1403 kg ha^{-1}) or, post-infection single spray of herbal mixture (1334 kg ha^{-1}) or, *panchagavya* (1294 kg ha^{-1}) enhanced the seed yield significantly over control (1088 kg ha^{-1}).

Screening for downy mildew resistance

Ten lines of DM series (DM-1 through DM-10) were screened under field conditions at Anand. However, difference in disease severity between the lines was nonsignificant.

Effect of planting time on downy mildew severity

A field experiment was conducted at Anand to monitor the effect of varying environmental conditions (by differing sowing dates) on downy mildew disease development. The crop was sown at 10 days interval starting from 20th October to 10th December. Downy mildew disease severity was high in the early sown crops and it gradually decreased with delay in sowing. Highest disease was in the crop sown at 20th October (23.80%) while lowest was in the December 10 sowing (2.50%). Number of effective spikes per plant also decreased with delay in sowing. However, seed yield was significantly highest in 10th November sowing (1040 kg ha^{-1}) and it was at par with November 20 sowing (981 kg ha^{-1}).

Effect of different irrigation schedules at varying sowing dates on yield

An experiment was conducted at Mandsaur to standardise the irrigation schedule under varying sowing dates. Sowing was done at five different dates at weekly interval starting from 1st November to 28th November. The crop was irrigated twice (at branching and before flowering), thrice (at branching, before flowering and after flowering) or, four times (before branching, after branching, before flowering and after flowering). Sowing on 21st November produced significantly higher seed yield (834 kg ha^{-1}). However, it was at par with sowing on 14th November (723 kg ha^{-1}). The lowest seed yield was recorded from 28th November sowing (501 kg ha^{-1}). Irrespective of sowing dates, the crop responded similarly to different irrigation levels. Maximum seed yield was produced with three (689 kg ha^{-1}) and two (687 kg ha^{-1}) irrigations. While seed yield was reduced to 660 kg ha^{-1} with application of four irrigations.

Influence of FYM, bio and inorganic fertilisers on nitrogen uptake

In an experiment conducted at NRCMAP, nitrogen was applied through inorganic (0, 20, 40 kg ha^{-1}), organic (0 and 5 tonnes ha^{-1} FYM) and biofertilisers (*Azotobacter* and *Azospirillum*) in different combinations. The study was conducted on two varieties (Niharika and GI-2). Application of FYM increased the nitrogen content of seed and straw over control. Consequently, N uptake increased from 63.84 kg ha^{-1} in control to 69.71 kg ha^{-1} in FYM application. The varieties did not differ significantly in terms of N content with FYM application. N contents in the seed (2.17%) and straw (0.70%) were highest with application of 40 kg ha^{-1} N through inorganic source. However, different bio- and inorganic fertilisers had non-significant effect on two varieties in terms of N content. N uptake was highest (74.31 kg ha^{-1}) with 20 kg ha^{-1} inorganic N. GI-2 recorded higher N uptake (68.82 kg ha^{-1}) compared to Niharika (64.73 kg ha^{-1}) with different inorganic N doses and biofertilisers. Application of FYM increased the nitrogen use efficiency with inorganic- and bio-fertiliser with the result N content increased from 2.10% to 2.14% in seed and from 0.67% to 0.71% in straw with FYM.

Nitrogen uptake of different varieties with different N fertilisers

To study the N uptake by two varieties (GI-2 and Niharika), two different fertilisers (urea and ammonium sulphate) were applied @ 20 and 40 kg N ha^{-1} in a field experiment at NRCMAP. Absolute control was also maintained. The N content of seed was not influenced by fertiliser source, N dose or varieties. However, N content in straw increased with the application of fertilisers. GI-2 was better N utiliser compared to Niharika. Highest N content was recorded with 40 kg N ha^{-1} applied through either source in GI-2 (0.89%). N uptake was higher with increasing levels of N through both the sources in both the varieties. Varieties did not differ significantly in terms of N uptake. Highest N uptake was recoded in GI-2 with application of 40 kg N ha^{-1} through ammonium sulphate (98.2 kg ha^{-1}). However, it was at par with the same N dose through urea in same variety (91.6 kg N ha^{-1}).

Effect of application of nitrogen in split doses on N uptake

To enhance the N use efficiency, 40 kg N was applied in three split doses at three growth stages (sowing, branching and flowering) at NRCMAP. The N content in seed and straw increased with application of fertiliser compared to control. Highest N content in seed (2.38%) was observed when nitrogen was applied in three split doses – 25% at sowing, 25% at branching and 50% at flowering. In straw, it was maximum (0.70%) when 25% N was applied at sowing and rest at flowering. N uptake was highest (91.08 kg ha^{-1}) when fertiliser was applied 50% at sowing and rest in two splits of equal amount at branching and flowering.

KALMEGH (*Andrographis paniculata*)

The plant is an annual herb belongs to the family Acanthaceae. The whole plant is medicinally useful. This bitter herb is well known under the name *Kalmegh or, green chiraita* and is widely used in the ISM. It is the source of several diterpenoids of which the bitter water soluble lactone, andrographoloid is important. The drug is used against fever, stomach disorder and as a bitter tonic. Collection and evaluation of the germplasm, understanding the reproductive biology, development of production technology including stress physiology, post harvest behaviour, etc. are some of the important areas of research. Kalmegh is cultivated in limited areas of several parts of India as a Kharif crop. The plant is well known as a hepatoprotective drug and immunomodulator.

Evaluation of elite lines

Six accessions of *Andrographis* collected from different parts of India were evaluated at Anand for quality yield. Significantly higher yield was obtained in accession number 3 (2844 kg ha^{-1}), which was at par with accession number 2, 1 and 4 (2632, 2518 and 2467 kg ha^{-1}). However, no significant difference was found in the case of andrographoloide content among the accessions studied.

Forty-three accessions were evaluated at NRCMAP based on plant height, number of branches, plant spread, herbage yield and andrographoloide content. Plant height ranged from 28.00 cm (IC-111286) to 73.73 cm (EC-415019) and plant spread ranged from 44.70 in IC-111286 to 113.50 cm in UP-1. Fresh and dry herbage yields were recorded highest in IC-342136 (290.6 g plant $^{-1}$ and 99.16 g plant $^{-1)}$ and lowest in IC-111286 (120.8 g plant $^{-1}$ and 32.12 g plant $^{-1)}$. Andrographoloide content (%) in stem was highest in IC-260035 and IC-210635 (0.365) and lowest in IC-342141 (0.09). However, andrographoloide content in leaf was highest in IC-342141 (4.67%) and lowest in accession from Bhubaneswar (1.28%).

LIQUORICE (*Glycyrrhiza glabra*)

It belongs to the family Papilionaceae. Stolons, the medicinally used part are used as expectorant. The crop is grown well under Haryana condition and glycyrrhizic acid is responsible for the therapeutic action. The dried, peeled and unpeeled underground stems and roots constitute the drug. In Greek, glycyrrhiza means 'Sweet Root'.

Germplasm evaluation

Twenty genotypes were evaluated with one check, HM-1 at Hisar. The data on diameter of bold stolon, medium stolon, thin stolon and fresh stolon yield were recorded. Genotype HMK-1-3 recorded highest diameter (2.15 cm) followed by HMK-6-2 (2.00 cm) against the check HM-1 (1.80 cm). Fresh stolon yield was higher in the genotype HMK-6-2 (161110 kg ha^{-1}) followed by HMK-1-3 (136110 kg ha^{-1}), HMK-7-1 (125000 kg ha^{-1}), HMK-7-4 (111110 kg ha^{-1}), HMK-1-2 (108330 kg ha^{-1}) and HMK-7-5 (105550 kg ha^{-1}) against check HM-1 (94440 kg ha^{-1}).

OPIUM POPPY (*Papaver somniferum*)

It is an annual herb belongs to the family Papaveraceae. The latex obtained mainly from the capsules contains several alkaloids, which are used in many medicinal preparations. The seed is also important as a culinary item. Its cultivation in the specific pockets of Madhya Pradesh, Uttar Pradesh and Rajasthan is strictly under the control of licensing from Central Bureau of Narcotics, Govt. of India. It is grown as a rabi season crop. Several analgesic, sedative, antispasmodic, hypnotic and anaesthetic drugs are manufactured from the opium latex.

Evaluation of germplasm

One hundred and eighteen germplasms from different centres along with four checks were evaluated in augmented design for different quantitative and qualitative traits at Faizabad. The plant height varied from 80.90 cm to 110.80 cm. It was found maximum in ND-11 followed by U.O.-390 (109.90 cm) and ND-12 (108.00 cm) and minimum in UOP-36.The maximum number of leaves per plant was in NBPGR-2 (20.70) followed by UO-1495 (20.3) and ND-40 (20.2) and minimum in UOP-17 (12.1). The maximum number of capsules per plant was in ND-47 (3.1) followed by ND-16, 17, 20, 26, 29, 36, 48, UO-1985 (3.0) and minimum in UOP-87 (1.10). Longest capsule was recorded in ND 03-2 (3.96 cm) followed by UOP-78 (3.92 cm) and NC 57928 (3.82 cm) and shortest in MOP-8 (2.38 cm). Widest capsule was noticed for the genotype ND-26 (4.32 cm) and the

narrowest in UOP-37 (2.20 cm). Width of sixth leaf from top was maximum in germplasm NC-57759 (12.38 cm) followed by NC-57928 (12.36 cm) and UOP-90 (12.19 cm) and minimum in NOP-03-6 (9.21 cm). Latest flowering entries were ND-10, ND-208, NOP 03-7, NC-57950 (all 107 DAS) and the earliest was UO-221 (70 DAS). Days to first flowering varied from 66 to 99 days. Lowest days were taken by UO-221 and the highest days by entry ND-8. Maximum latex yield was recorded for the genotype 1385 (42.70 kg ha^{-1}) followed by ND-17 (38.83 kg ha^{-1}) and ND-03-02 (37.87 kg ha^{-1}) and minimum in UOP-37 (1.58 kg ha^{-1}). Maximum seed yield was recorded in the genotype NOP-03-1 (958 kg ha^{-1}) followed by ND-20, 23 (916 kg ha^{-1}) and minimum in MOP-8, UOP-12, 68, 82 (41 kg ha^{-1}). Maximum husk yield was recorded in ND-20 (833 kg ha^{-1}) followed by ND-23 (750 kg ha^{-1}) and UO-1385 (729 kg ha^{-1}) and minimum in UO-17682 and UOP-37 (41 kg ha^{-1}).

In another trial conducted at Mandsaur using two hundred and thirty five germplasm lines collected from Mandsaur (110), Faizabad (59) and Rajasthan (66) revealed higher range of variability for plant height which ranged from 90.2 cm (NC-57913) to 113.0 cm (IC-11). Leaf length varied from 14.0 cm (MOP-1083) to 30.0 cm (MOP-581), leaf breadth from 8.2 cm (P_4 x P_{10}) to 16.0 cm (IC-8). Type of leaf was serrated in IC-44, NOP-4 and ND-1001 and in others it was non-serrated. Number of leaf per plant varied from 12 (MOP-1078) to 17 (MOP-570), flower colour was white (MOP-542, JA-16, MOP-1078), rani (MOP-409, MOP-1057), pink (MOP-516, MOP-571, IC-42), dark red (MOP-409), light red (MOP-1057) or violet (UOP-67). Peduncle type was found non hairy in all except in MOP-536 and NBRI-8. Capsule size was highest (4.5 x 4.7 cm) in IC-7, MOP-572 and lowest (3.2 x 3.2 cm) in (IC-18). Latex yield (kg ha^{-1}) ranged from 11.91 kg (IC-19) to 77.45 (MOP-1069) and seed yield (kg ha^{-1}) ranged from 208 kg (IC-95) to 1249 kg (NBRI-5). Morphine percent ranged from 12.4 to 17.3. Thebaine content was recorded low in MOP-1074, medium in MOP-575 and high in MOP-513.

Evaluation and multiplication of selected lines

Thirty selected entries were evaluated and seed multiplied for future breeding programme. The variability was observed in flower colour (white, pink and red). Both serrated as well as non-serrated petals along with non-hairy peduncle were observed.

Latex yield ranged from 45.68 kg ha^{-1} (IC-88) to 103.27 kg ha^{-1} (MOP-1086). Highest latex yield was in MOP-1086 (103.27 kg ha^{-1}) followed by MOP-379 (101.27 kg ha^{-1}), MOP-1080, MOP-1085, MOP-1084, MOP-1078 and MOP-1087 (more than 90 kg ha^{-1}).

Seed yield ranged from 611 kg ha^{-1} (MOP-585) to 1417 kg ha^{-1} (MOP-379). Highest seed yield was in MOP-379 (1417 kg ha^{-1}) followed by MOP-1080 (1319 kg ha^{-1}), MOP-528 (1292 kg ha^{-1}) and MOP-1069 (1208 kg ha^{-1}). However yield of husk ranged from 472 kg ha^{-1} (MOP-585) to 1361 kg ha^{-1} (MOP-379). Highest yield was in entry MOP-379 followed by MOP-1079, MOP-528 and IC-42.

Multilocation evaluation trial of advance lines

Eight lines (PS-1, PS-2, PS-3, PS-4, PS-5, PS-6, PS-7 and PS-8) from different centres were tested against two checks *viz*. NOP-1 and NOP-4 at Faizabad and against IC-42 (National check) and JA-14 (local check) at Mandsaur. The data recorded were latex yield, seed yield and husk yield.

At Faizabad, latex yield varied from 11.42 kg ha^{-1} to 22.95 kg ha^{-1}. The maximum latex yield was in PS-5 (22.95 kg ha^{-1}) followed by NOP-4 (22.37 kg ha^{-1}) and NOP-1 (22.08 kg ha^{-1}) and minimum in PS-1. None of the entries performed significantly better than the checks. At Mandsaur, latex yield (kg ha^{-1}) ranged from 43.5 kg to 71.5 kg. The highest latex yield was in PS-2 (71.5 kg ha^{-1}) followed by PS-8 (67.3 kg) and PS-6 (64.05), which were significantly superior to the National check as well as the local check (Fig. 8).

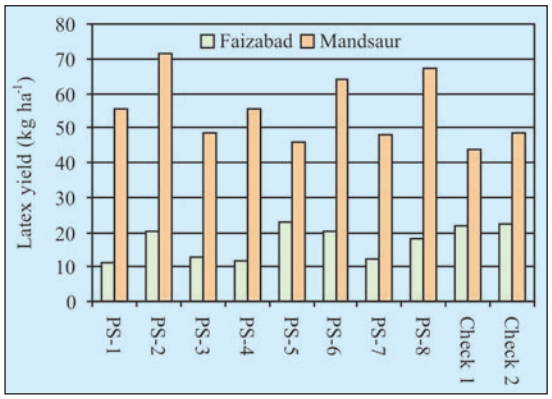


Fig. 8. Latex yield in multilocation evaluation trial of opim poppy at Mandsaur

Seed yield ranged from 3320 kg ha^{-1} to 753 kg ha^{-1} at Faizabad. None of the entries produced more yield than checks. However at Mandsaur, significantly superior seed yield was in PS 1 (1191 kg ha^{-1}) in comparison to both the checks as well as the other entries, however, PS-4 and PS-2 outperformed only the local check (1179 kg ha^{-1} and 1172 kg ha^{-1}).

Maximum husk yield was recorded for NOP-1 (541 kg ha^{-1}) followed by NOP-4 (503 kg ha^{-1}) and minimum for PS-1 (204 kg ha^{-1}) at Faizabad. At Mandsaur, husk yield ranged from 574 (PS-5) to 965 kg ha^{-1} (PS-6) . However, none of the entries could outperform both the checks. Morphine content varied from 11.8 (PS-4) to 15.1 percent (IC-42) but highest morphine yield was in PS-2 (10.01 kg ha^{-1}), which was higher than National check IC-42 (7.349 kg ha^{-1}).

Evaluation of selected lines

Twelve selected lines namely NOP-02-1, NOP-02-2, NOP-02-3, NOP-02-4, NOP- 02-5, NOP-02-6, NOP-02-7, NOP-02-8, NOP-02-9, NOP-02-10, NOP-02-11 and NOP-02-12 were tested at Faizabad with two local checks i.e. NOP-1 and NOP-4 for three major characters *i.e.* latex yield, seed yield and husk yield.

Latex yield varied from 10.32 kg ha^{-1} to 24.06 kg ha^{-1}. Maximum latex yield was recorded for NOP-02-6 (24.06 kg ha^{-1}) followed by NOP-02-5 (22.88 kg ha^{-1}) and NOP-02-4 (20.83 kg ha^{-1}). The performance of lines NOP-02-6 and NOP- 02-5 were significantly higher than both the checks. However, in rest of the entries latex yield was either at par or lower than the check.

Seed yield varied from 437 kg ha^{-1} to 792 kg ha^{-1}. The maximum seed yield was recorded in NOP-02-5 (792 kg ha^{-1}) followed by NOP-02-7 (746 kg ha^{-1}) and minimum in NOP-02-1.

Husk yield varied from 345 kg ha^{-1} to 624 kg ha^{-1} for NOP-02-1 and NOP-02-3, respectively.

Evaluation of selected hybrid progenies

Seven selected hybrid progenies (F_7 generation) *viz*., NOP-02-13, NOP-02-14, NOP-02-15, NOP-02-16, NOP-02-41, NOP-02-49 were tested against three checks *i.e.* NOP-1, NOP-4 and UO-285 for latex yield, seed yield and husk yield.

The latex yield ranged from 7.71 kg ha^{-1} to 24.15 kg ha^{-1}. The maximum latex yield was recorded for NOP-02-49 (24.15 kg ha^{-1}) followed by NOP-02-13 (23.93 kg ha^{-1}) and minimum for NOP-02-51. None of the entries performed significantly better than the check NOP-4 (21.35 kg ha^{-1}) and NOP-1 (21.02 kg ha^{-1}).

Seed yield ranged from 350 kg ha^{-1} (UO-285) to 791 kg ha^{-1} (NOP-02-49). The entries NOP-02-49, NOP-02-13 and NOP-02-41 recorded significantly higher seed yield than check.

Husk yield ranged from 194 kg ha^{-1} to 589 kg ha^{-1} for UO-285 and NOP-02-49, respectively. Only NOP-02-49 performed significantly better than the checks.

Heterosis study

During the year 2003-04, thirty lines were crossed with two testers *viz*; JOP-539 and JOP-540 and 60 crosses were made. These crosses along with parents (32) were grown and evaluated for latex, seed, husk and morphine yields during the year 2004-05. Out of sixty cross combinations, only four crosses viz; MOP-379 x JOP-540, MOP-509 x JOP-540, MOP-536 x JOP-539 and MOP-278 x JOP-540 exhibited more than 10 percent heterosis for latex yield. Similarly for seed yield four crosses viz; MOP-511 x JOP-539 (22.95 %), MOP-379 x JOP-540 (19.51), MOP-509 x JOP-540(13.68 %) and MOP-700 x JOP-539 (10.65 %) exhibited heterobeltiosis. Three crosses viz; MOP-585 x JOP-539, MOP-506 x JOP-539 and Shyama x JOP-539 exhibited 8.33 per cent heterosis in the case of husk yield. Morphine content showed more than 19 per cent heterosis in six crosses. Highest morphine yield was in crosses, MOP-379 x JOP-540 (12.91 kg ha^{-1}), followed by MOP-536 x JOP-539 (12.256 kg ha^{-1})and MOP-511 x JOP-539, MOP-700 x JOP-539 and MOP-506 x JOP-539 (more than 10 kg ha^{-1} morphine).

On the basis of over all performance, the crosses viz; MOP-379 x JOP-540, MOP-509 x JOP-540, MOP-536 x JOP-539, MOP-278 x JOP-540 for latex yield and crosses *viz*; MOP-511 x JOP-539, MOP-379 x JOP-540, MOP-509 x JOP-540 and MOP-700 x JOP-539 were identified as superior cross combination for higher seed yield. Three crosses *viz*; MOP-585 x JOP-539, MOP-506 x JOP-539 and Shyama x JOP-539 recorded 8.33 per cent heterosis over the better parent. The highest morphine content of 20.8 per cent was recorded by MOP-506 x JOP-539. However, five crosses *viz*; MOP-379 x JOP-540, MOP-700 x JOP-539, MOP-506 x JOP-539 and MOP-511 x JOP-539 recorded more than 10 kg morphine yield (kg ha^{-1}).

Four crosses *viz*; MOP-379 x JOP-540, MOP-509 x JOP-540, MOP-536 x JOP-539 and MOP-278 x JOP-540 for latex yield, four crosses *viz*; MOP-379 x JOP-540, MOP-511 x JOP-539, MOP-509 x JOP-540 and MOP-700 x JOP-539 for seed yield, three cross *viz*; MOP-285 x JOP-539, MOP-506 x JOP-539 and Shyama x JOP-539 for husk yield and five crosses *viz*; MOP-379 x JOP-540, MOP-536 x JOP-539, MOP-700 x JOP-539 and MOP-506 x JOP-540 for higher morphine yield (more than 10 kg ha^{-1}) were identified as superior cross combinations on the basis of first year results.

Effect of varying levels of nitrogen supplementation from organic sources

To find out the optimum level of nitrogen supplements with organic sources for economic yield, an experiment was conducted at Faizabad. Supplementation of nitrogen was done through two organic sources (FYM and vermicompost) while keeping the P and K constant through inorganic sources. N was supplemented from 0% to 100% through organic sources. Appropriate control with no extra nutrients was also maintained.

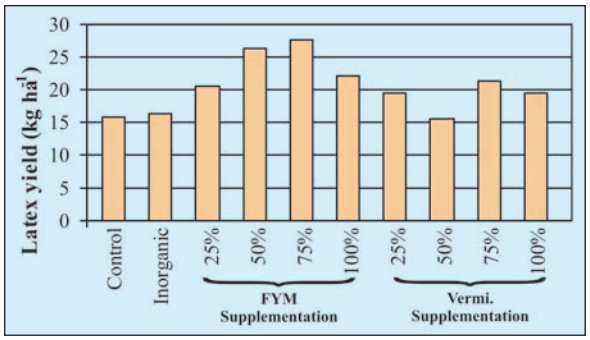


Fig.9. Latex yield under the influence of FYM and vermicompost in opium poppy at Faizabad

Plant height varied from 94.27 cm to 103.73 cm due to various treatments. Maximum plant height (103.73 cm) was recorded with the application of N 100% through FYM + recommended doses of P & K as compared to other treatments. However, it was at par with all the other treatments where FYM was applied and in 100% inorganic fertiliser application. Minimum plant height was observed in control. Latex yield varied from 15.78 kg ha^{-1} to 27.69 kg ha^{-1} between the treatments. Application of FYM significantly enhanced the latex yield as compared to application of vermicompost (Fig. 9). Highest latex yield was obtained with 75% of N supplementation through FYM. However, it was at par with 50% N supplementation through FYM. Minimum latex yield was recorded in the control. Interestingly, nutrient application solely through inorganic fertilisers produced only 16.20 kg ha^{-1} of latex and among the treatments receiving vermicompost, highest latex yield of 21.42 kg ha^{-1} was recorded from 75% N supplementation. Significantly highest seed yield (791 kg ha^{-1}) was obtained from 75% FYM supplementation. Application of 75% N through FYM was found significantly superior (576 kg ha^{-1}) over other treatments in terms of husk yield. Lowest yield (396 kg ha^{-1}) was recorded in control. Among the vermicompost applications, highest seed (659 kg ha^{-1}) and husk (517 kg ha^{-1}) yields were obtained from 100% organic source. These values were 482 kg ha^{-1} and 416 kg ha^{-1} in case of 100% inorganic fertiliser application.

Biological management of primary infection of downy mildew

An attempt was made at Faizabad to minimise the use of chemical fungicide in management of primary infection of downy mildew. *Trichoderma viride* multiplied over enriched crushed seeds of sorghum for 15 days was used as the bio-agent (BA). It was used either as seed treatment (at 10 g kg^{-1} seeds), foliar spray (100 g BA in 1 lt water, at 35 and 55 DAS) or, soil application. For soil application, BA was mixed with well-decomposed cow dung (1:25) and incubated under shade in humid condition for 20 days. This was mixed with the soil of seed row before sowing (at 25 kg $acre^{-1}$). Appropriate control was also maintained. Application of BA significantly reduced the primary infection. Minimum primary infection (16.66%) was noticed when BA was applied as seed treatment, soil amendment and foliar sprays. However, it was at par with that of only seed and soil application (16.92%). This suggested that application of BA as foliar spray

did not have much effect in reducing the disease incidence. Maximum primary infection was recorded in control (18.92%). Maximum yields of latex (23.39 kg ha^{-1}), seed (594 kg ha^{-1}) and husk (499 kg ha^{-1}) were obtained from minimum disease incidence. However all these were at par with next best treatment (19.77, 535 and 475 kg ha^{-1}, respectively).

In a similar study carried out at Mandsaur, application of *Trichoderma* sp. was found to significantly reduce the primary infection to 6.66% compared to 11.61% in control. Consequently, this treatment increased the latex yield by 13.67% as compared to control.

Effect of host age on development of downy mildew

Surface sterilised seeds of opium poppy cv Kirtiman were sown in steam sterilized pot soil on 4 different dates at weekly interval starting from 25th October to 15th November. The plants (3 in each pot) were raised in a net house. The experiment was conducted when the ambient temperature was low (7-27^{o}C) and RH was high (83-90%). Plants aged between two months to 35 days were shifted to heavily infected field, in a growth chamber or, left in the net house. The growth chamber was programmed to closely resemble natural conditions favourable for infection. The plants were inoculated with conidial suspension (15,000 ml^{-1}). The plants kept under field conditions and in the net house were sprayed 2 h before sunrise leaving fine droplets of spore suspension over leaf surface. After inoculation, the plants in net house were kept under shade for 24 h and in growth chamber for 24 h kept in dark condition. Seven days after inoculation pale yellow brown spots appeared on leaves of inoculated plants both in growth chamber and net house. The spots were more conspicuous and larger in size over plants in growth chamber. Symptoms on the upper 3-4 leaves were not prominent. About 10 days after inoculation, few minute brown spots appeared on lower leaves of the plants kept in field. However, there was no difference in symptom production among plants of different age.

Inoculation technique to reproduce secondary infection of downy mildew under natural condition

To develop a suitable inoculation technique for reproduction of symptoms after infection, three methods were tried at Faizabad. Healthy 3 months old plants grown in pots in net house were used. The plants were either placed amid heavily infected field, sprayed with conidial suspension (15,000 ml^{-1}) or kept in net house. In the third set, a small piece of (2x2 mm^2) infected leaf with abundant conidia growing over lower surface was fixed over both upper and lower surface of healthy leaves of the potted plants after spraying water over the plants. The plants were kept under shade and high moisture was maintained by repeated spraying of water. The piece of leaves was removed after 48 h. Among the three methods of inoculation, spraying of conidial suspension over plants produced better disease symptoms. Many pale brown spots appeared on the leaves particularly near the edge of the lamina. Under high humid condition these spots also increased in size. On the leaves inoculated with piece of diseased leaves, no such brown spots developed. When the leaf pieces were removed, the contact portions of the inoculated leaves looked black and necrotic. On the plants exposed to air borne conidia in field, the symptom expression was not very much prominent. On lower leaves of potted plants scattered, small and discoloured spots appeared.

Screening for disease resistance

A total of 110 genotypes were screened under the field condition for resistance against downy mildew disease at Mandsaur and resistant genotypes are as follows:

Resistant: JOP-539, MOP-1078, MOP-1079, MOP-1080, MOP-1081, MOP-1082, MOP-1083, MOP-1084, MOP-1085, MOP-539.

These lines were also scored for disease resistance against powdery mildew and resistant genotypes are as follows:

Resistant: MOP-575, MOP-513, MOP-510, MOP-585, MOP-187, MOP-1057, MOP-379, MOP-537, MOP-587, MOP-518, MOP-506, MOP-571, MOP-581, MOP-1054, MOP-570, MOP-514, MOP-508, MOP-519, MOP-528, IC-30, IC-8, NC-57913, ND-2001, ND-1001, Posta-149, Brop –1, P_4 X P_{10}.

Chemical characterization of the germplasm

Since demands for non-morphine alkaloids like thebine and codine are increasing, an attempt was made at Mandsaur to characterise 50 lines according to their alkaloid contents.

High codine lines: MOP-587, MOP-533, MOP-532, IC-19, IC-114, NBPGR-2, Sweta, NOP-530, UO-201 and MOP-541 (all containing codine more than 4%). NOP-530 and UO-201 contained more than 5% codine.

High Thebain lines: MOP-278, MOP-581, MOP-1054, IC-114, IC-19, POSTA-149, MOP-541, UO-602 and JA-16 (all containing more than 2.5% thebine. MOP-541 contained 4.33% thebine)

High Narcotine lines: MOP-1074, MOP-537, MOP-581, MOP-504, MOP-541, MOP-503, MOP-513, IC-114, UO-201 (all having narcotine more than 7.0%. MOP-541 had 8.98 % narcotine.

Some of the lines were found to contain high concentrations for more than one alkaloids. IC-114 and MOP-541 were having higher concentrations of all the three alkaloids.

SAFED MUSLI (*Chlorophytum borivilianum*)

Chlorophytum borivilianum commonly known as Safed musli is widely distributed in the forests of Maharashtra, Gujarat, Rajasthan and Madhya Pradesh. It is being used as raw material for preparation of many ayurvedic vital tonics and also is in great demand. Forests are major source of raw material to the Industry. Collection and conservation of superior genotypes in terms of quality and productivity are need of the hour. The plant belongs to the family Liliaceae. Fasciculated roots of the plant are medicinally useful. Saponins present in the root are the active ingredient. It is a kharif crop and requires humus rich soil.

Evaluation of germplasm

Twenty-four germplasm lines of safed musli were evaluated at Mandsaur and wide range of variability was noticed among the various germplasm. Length of leaves varied from 15 cm (MCB-415) and 28cm (MCB-401). Breadth of leaves ranged between 14 mm (MCB-412) to 28mm (MCB-409). Colour of anther that is a prominent genetic character ranged from yellow to light yellow or sometime light green. Number of fasciculated roots per bunch was minimum in MCB-411 (5.2) and maximum (16.6) in MCB-416, length of fasciculated root ranged from 7.4 cm (MCB-412) to 11.0 cm (MCB-416); similarly great difference was found in fresh weight of fleshy roots per bunch and moisture content. Total steroidal sapogenine content (%), which is a basic parameter for quality of material, also ranged from 0.625 (MCB-416) to 1.180 (JSM-405, check). Yield of fresh fasciculated root varied from 375 kg ha^{-1} (MCB-420) to 1937 kg ha^{-1} (MCB-404). The highest fasciculated root yield in MCB-404 (1937 kg ha^{-1}) followed by MCB-414 (1916 kg ha^{-1}), MCB-418 (1906 kg ha^{-1}), MCB-412 (1895 kg ha^{-1}) and JSM-405 (1823kg ha^{-1}). The tips of the root were either pointed or blunt.

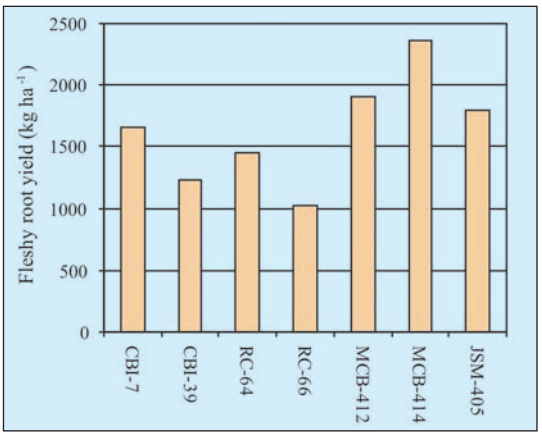


Fig 10. Evaluation of elite lines of safed musli at Mandsaur

Seven advance lines were tested at Mandsaur. Entry MCB-414 recorded significantly higher fleshy root yield (2357 kg ha^{-1}) followed by MCB-412 (1901 kg ha^{-1}) than the check JSM-405 (1796 kg ha^{-1}) (Fig. 10). Moisture content varied from 72 to 78 percent. Sapogenine content was highest in JSM-405 (1.15 %) followed by MCB-412 (0.88%), MCB-414 and CBI-39 (0.85%). Maximum fresh weight of fasciculated root per plant was recorded by CBI-7 (15.8) and minimum was recorded by CBI-39 (11.5). Similarly, number of fleshy roots per plant ranged from 10.0 (RC-66) to 13.8 (JSM-405), maximum length of fasciculated root was recorded by CBI-7 (8.7 cm) while minimum length (7.5 cm) was recorded by CBI-39 and RC-64 and diameter of fasciculated root varied from 0.54 cm to 0.68 cm.On the basis of fresh fasciculated root yield and other yield contributing characters, entries MCB-414 and MCB-412 were found superior.

Twelve germplasm accessions of safed musli were evaluated at Hisar based on number of leaves, leaf length and breadth, fresh fleshy root yield per plant and different fleshy root characters. Number of leaves ranged from 16 (RC-66) to 40 (MCB-414), leaf length 26 cm (RC-64 & 66) to 40 cm (MCB-414) and leaf breadth 1.6 cm (RC-64) to 2.6 cm (CBI-7). Fleshy root yield ranged from 20 g $plant^{-1}$ in CBI-39 to 143 g $plant^{-1}$ in CBI-7, fleshy root length ranged from 8.30 cm (HCB-2) to 18.00 cm (HCB-5), fleshy root diameter 6.20 mm (MCB-405) to 8.20 mm (HCB-2) and number of fleshy root per plant from 8.30 (HCB-2) to 24.30 (MCB-414).

Twenty five accessions were evaluated at NRCMAP and no significant differences were found among the accessions in the case of number of leaves per plant,

shoots per plant and inflorescences per plant. Leaf breadth and leaf area varied significantly among the accessions. Leaf breadth varied from 1.62 cm in RAJ-2 to 2.38 cm in RAJ-7. RAJ-7 was at par with MP-5 (2.26 cm), GUJ-4 (2.22 cm), MH-2(2.21cm) and MP-6 and 7 (2.16 cm). Leaf area was recorded maximum in MP-7 (68.44cm^2) followed by MP-5(62.81cm^2) and GUJ-4 (60.06 cm^2). Leaf area was lowest in RAJ-1 (30.89 cm^2). Fresh fasciculated root yield ranged from 5.77 g plant^{-1} in GUJ-1 to 23.77 g plant^{-1} in RAJ-11. Number of fleshy roots per plant was highest in GUJ-2 (20.43 g) and it was lowest in GUJ-1(4.30 g). Length of fleshy root ranged from 1.97 cm (GUJ-1) to 9.26 cm (MP-4).

Registration of germplasm

Two safed musli lines (NRCCB-1 and NRCCB-2) developed from NRCMAP were registered by the National Germplasm Registration Committee as INGR No. 04113 and INGR No. 04114. The characters taken into consideration for INGR 04113 were the long fleshy root (>10 cm) with blunt end, dark coloured skin and converged type of fleshy root arrangement. In the case of INGR-04114, the characters registered were its shorter fleshy root (<10 cm), light coloured fleshy roots and diverged type of fleshy root arrangement.

Standardisation of micro-propagation technique

To maximise the shoot multiplication under tissue culture conditions, an experiment was conducted at NRCMAP. The germinated shoot bud explants derived from stem disc was used for multiplication on basal half strength MS media supplemented with BA, kinetin, NAA, IAA and adenine sulphate. The medium with BA and adenine sulphate helped in the rapid multiplication of shoots. The rate of shoot multiplication was maximum on the medium containing BAP, adenine sulphate and NAA in different proportions. This treatment produced maximum (11.2) shoots per culture within 4 weeks (Fig. 11).

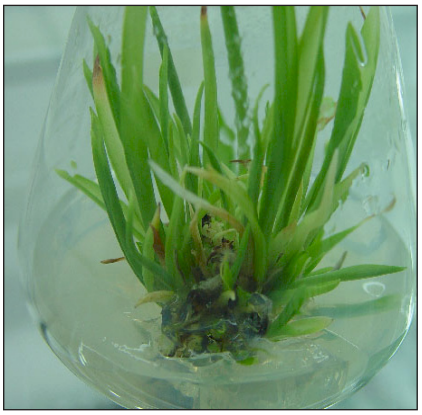


Fig.11. Shoot multiplication in safed musli at NRCMAP

It was difficult to maintain primary shoot cultures for long periods because of the gradual decline in the nutrient supply and dehydration of the medium in the culture vessel. In order to examine the effect of repeated subculturing on shoot production and growth, the cultures were maintained in an incubation room at 25±2^{0}C and 4500 lux light intensity under a 16 hr photoperiod. Sub-culturing was done at an interval of 4 weeks. A propagation profile was prepared for a total of 8 subcultures. It was observed that there was gradual increase in the shoot production rate till the 8th subculture.

Three auxins *viz*. NAA, IAA and IBA were tested for rooting of the micro-propagated shoots. The hormones were used at 0.0, 0.05, 0.1, 0.25 and 0.5 mg l^{-1} concentration in the ½ MS medium supplemented with sucrose under standard culture condition. There was no sign of rooting in the media devoid of auxins. The average number of root per shoot significantly varied with different concentrations of

IAA, IBA and NAA. At higher concentration of IAA, IBA and NAA, the rate of initiation declined rather callus developed at the basal ends. IBA induced poor rooting even when cultures were kept for 2 weeks. About 90-95% of the excised shoots were rooted within 11-12 days on medium containing IAA at a standardised concentration. The maximum percentage of rooting (95.2%) and the maximum number of roots per shoot (15.8 ± 0.3) were observed on this medium.

For acclimatisation, general schedule that followed included transfer of thoroughly washed rooted plantlets from agar culture to small poly bags containing sterile mixture of sand: soil: FYM (1:1:1) and thereafter the plants were kept in the climate controlled greenhouse and transferred to earthen pots after two weeks. Watering was done at every two days intervals. After two weeks of hardening, the plantlets were kept in the mist house under partial shade for two weeks before being finally shifted to the natural light. About 90-95 % of the micropropagated plants grew normally.

Somatic embryogenesis

The rapidly proliferation friable calluses derived from peduncle explants were used for induction of somatic embryogenesis. Callus pieces (ca. 500 mg) were taken from the callusing medium and put onto the induction media for somatic embryogenesis. Different concentrations of BA, Kn, GA_3, NAA and adenine sulphate were tested as supplements in ½ MS basal medium. The frequency of embryogenic callus production varied from 55.4% to 86.8% in peduncle derived calluses depending on the concentration of auxins and cytokinins tested. The number of somatic embryos per culture varied from 33.5 to 66.4 depending on the growth regulators used. Numerous white globular clumps of somatic embryos developed over the entire surface of the callus on ½ MS basal medium supplemented with Kn, GA_3 and NAA after 4 weeks of culture. The ability of the calluses to become embryogenic declined with an increase in the concentration of either IAA or NAA. The frequency of production of somatic embryos in the cultures was maintained for prolonged periods.

About 8.7-56.2% somatic embryos showed germination on ½ MS medium having kinetin within 2 weeks of transfer. Although BA and Ads helped the germination of somatic embryo but the percentage of germination was low as compared with the medium having Kn. The somatic embryos developed distinct plumules with roots (56.2%) on ½ MS medium supplemented with 0.10 mg 1^{-1} kinetin within 10 days of culture. Addition of NAA in the germination medium inhibited embryo germination. On an average 50-55 somatic embryos germinated in to plantlets per 150 mg of embryogenic callus. Among the plantlets subjected to acclimatization, 72% survived under green house conditions. The plants grew well in the mist house; no morphological differences were observed.

Effect of removal of inflorescence on the growth and yield

An attempt was made at Anand to increase the fleshy root yield by diverting the energy from reproductive developments. Inflorescence was removed regularly from the plants and appropriate control was also maintained. Removal of inflorescence (detopping) increased the vegetative growth, yield parameters and fleshy root yield. Leaf length was increased by 21.08% in the detopped plants compared to control

(24.71 cm). Number of leaves per plant was significantly increased form 14.85 cm to 26.45 cm due to the treatment. Girth of the fleshy root increased to 2.75 cm from 2.04 cm after detopping. As a result, fresh fleshy root yield recorded significant increase of 31.70% in the detopped plants over control. Fleshy root yield was 6764.56 kg ha^{-1} after detopping compared to 5136.19 kg ha^{-1}.

Effect of different plant population on yield

Three plant populations (3.33, 2.22 and 1.56 lakhs) were compared at Anand which were maintained by planting single fleshy root at three spacings (30x10, 20x10 and 10x10 cm, respectively). Weight of fleshy roots per plant increased with increase in plant population. Whereas, number of fleshy roots per plant and length of fleshy root showed reverse trend. However, difference between the treatments was nonsignificant. Girth of the fleshy root was significantly more in the wider spacing. Thick fleshy root (2.55 cm) was obtained from 2.22 and 1.56 lakhs plant population while it was 2.41 cm in 10x10 cm spacing. Different plant populations significantly influenced the fresh fleshy root yield. Significantly highest fleshy root yield (11855 kg ha^{-1}) was obtained from 10x10 cm spacing (Fig. 12). Fresh fleshy root yields of 8482 and 7589 kg ha^{-1} were obtained from 20x10 and 30x10 cm spacing, respectively. Increase in fleshy root yield increased the total income highest being Rs. 2265400 recorded from closest spacing and minimum (Rs. 1343800) from 10x10 cm spacing. However, requirement of higher planting material for the closer spacing increased the cost of production to Rs 413822 to maintain the highest plant population. Even thennet profit was highest (Rs. 1851578) in this treatment and lowest (Rs. 1156148) in wider spacing of 30x10 cm. However, cost: benefit ratio was highest (1:6.16) with lowest plant population and minimum (1:3.72) in 20x10 cm spacing.

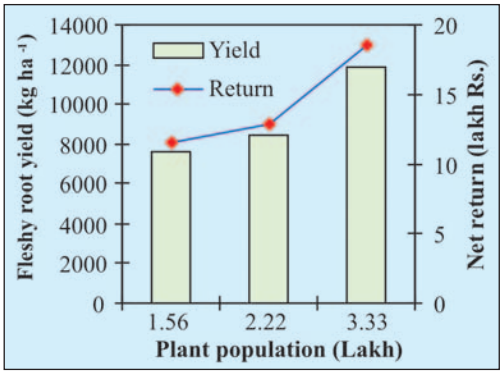


Fig.12. Fleshy root yield and net return in safed musli at Anand

Effect of different fertility levels on yield

Different levels of macronutrients were applied in different combinations to optimise the fleshy root yield at Mandsaur. Five levels of nitrogen (0, 15, 30, 45 and 60 kg ha^{-1}), seven levels of phosphorous (0, 10, 20, 30, 40, 60 and 80 kg ha^{-1}) and seven levels of potash (0, 10, 20, 30, 40, 60 and 80 kg ha^{-1}) were used in eleven different combinations along with control. Fresh fleshy root yield was affected due to incessant rain and water logging however, significant difference could be observed due to different fertility levels. All nutrient doses produced significantly higher fresh fleshy root yield than control (1049 kg ha^{-1}). Significantly higher fresh fleshy root yield was observed from $N_{45}P_{60}K_{60}$ (2139 kg ha^{-1}), which was at par with $N_{30}P_{40}K_{40}$ (2083 kg ha^{-1}).

Effect of time of harvest on root yield and quality

To determine the stage of harvesting for maximum fleshy root yield and saponin content at Akola condition, the crop was harvested at 30 days interval

starting from 90 days after planting (DAP) up to 240 DAP. Fresh and dry fleshy root yields were significantly influenced by the crop age at harvest. Significantly highest fresh fleshy root weight per plant was obtained with harvesting at 180 DAP (32.30 g) while minimum was at 90 DAP (23.34 g). Fresh fleshy root yield was also highest when crop was harvested at 180 DAP (2071 kg ha^{-1}). It was at par with harvesting at 150 DAP (2018 kg ha^{-1}). However, dry fleshy root yield was highest at 240 DAP (734 kg ha^{-1}) and at par with 180 DAP (705 kg ha^{-1}) and 210 DAP (727 kg ha^{-1}). The moisture content in fresh fleshy root was found to decrease with increasing age of crop. Significantly highest moisture content was recorded at 90 DAP (84.19%) and lowest was at 240 DAP (75.59%). However, saponin content showed a decreasing trend with the age of crop. Significantly lowest saponin was recorded at 240 DAP (6.22%) which was at par with 210 DAP (6.23%). Significantly highest saponin yield was produced by the treatment of 180 DAP (50.29 kg ha^{-1}) and it was at par with 210 DAP (45.91 kg ha^{-1}) and 240 DAP (45.71 kg ha^{-1}).

Effect of various planting methods on productivity and quality

An experiment was conducted at Udaipur to select the appropriate method of planting. Four different planting methods (on flat beds at 30 x 15 cm, on 7 inch high ridges at 30 x 15 cm, in furrows at 30 x 15 cm and on raised beds at 18 x 15 cm) were tried. Plant population was kept uniform in all the treatments.

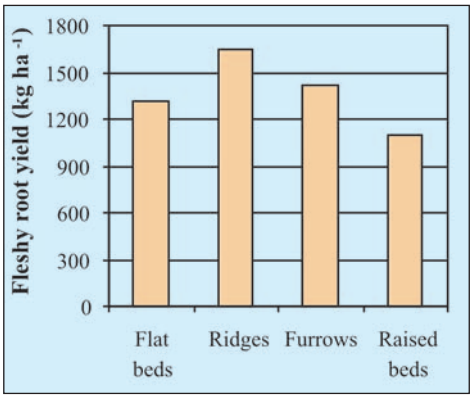


Fig.13. Influence of planting methods on fleshy root yield of safed musli at Udaipur.

All the yield attributes and fresh fleshy root yield were recorded maximum in the ridge planting. Significantly maximum number of fleshy root per plant (8.37) and length of main fleshy root (7.34 cm) were also obtained from this treatment. As a result, fresh fleshy root yield was highest (1645 kg ha^{-1}) in ridge planting method (Fig. 13). Planting in furrows yielded 1422 kg ha^{-1} fleshy root. Lowest yield (1104 kg ha^{-1}) was recorded in raised bed method. Sapogenin content varied from 0.68 to 0.69% and did not vary significantly due to planting methods. However, sapogenin yield significantly varied because of yield difference of fleshy root. Maximum sapogenin yield of 2.766 kg ha^{-1} was obtained from ridge method of planting compared to other methods.

Yield loss assessment due to foliar and fleshy root rot diseases

To assess the yield loss due to diseases, experiments were conducted at Mandsaur following paired plot method. Among the foliar diseases, leaf blight caused by *Macrophomina* sp. and anthracnose caused by *Colletotrichum* sp. was major. Need based sprays of 0.1 % carbendazim was applied for disease management in protected plots while control plots received no sprays. Disease incidences of 18% and 21% were recorded from the protected plots for blight and anthracnose diseases, respectively. The values were (35.85 and 45.21%), respectively significantly higher in the control plots. Fresh fleshy root yield was

1889 kg ha^{-1} from the protected plots compared to 1580 kg ha^{-1} from control plot. Hence, foliar diseases caused 16.35% yield loss.

Fleshy root rot caused by *Fusarium solani* was the major problem. Under protected plots, planting material was treated with Bavistin @ 0.15% before planting while no fungicide was applied in the control plots. Fleshy root rot incidence of 17.28% was observed in the treated plots while control plots recorded significantly higher (42.31%) disease incidence with the result, significantly higher fresh fleshy root yield (2276 kg ha^{-1}) could be obtained from the protected plots which was 23.41% higher than the control plots (1743 kg ha^{-1}).

Integrated management of fleshy root rot wilt

An experiment was conducted at Mandsaur to develop proper management of fleshy root rot disease. Soil application of potash @ 60 kg ha^{-1} and *Trichoderma viridi* @ 5 kg ha^{-1} and/or, seed treatment with Bavistin @ 0.15% were either used single or in different combinations. Combined treatment of potash, Trichoderma and Bavistin produced significantly lowest fleshy root rot incidence (14.15%). Highest fleshy root rot incidence (46.17%) was recorded in control. Effective disease suppression produced significantly highest fresh fleshy root yield (2410 kg ha^{-1}) from combination treatment receiving all inputs. This was 46.68% higher than the control plot (1643 kg ha^{-1}).

Post harvest deterioration of saponin content in dry fleshy root powder

To determine the shelf life of fleshy root powder, an experiment was conducted at Akola. Fleshy roots were harvested in the month of February, cleaned and dried by two methods viz .sun drying for three days and oven drying at 60° C for 24 hours. Then root powder was prepared and stored for one year in open container and airtight container. The observations in respect of moisture and saponin content were recorded at an interval of two months.

Quality of fleshy root powder, in terms of saponin content decreased with storage. Saponin content was found significantly reduced after 6 months of storage (6.16%) compared to that of 2 months (6.33%) and 4 months (6.31%) of storage. Significantly lowest content was recorded after 12 months of storage (5.79%). Among the methods of storage, saponin content was lowest when sun dried material was kept in open container (6.02%) as compared to other storage methods. Highest saponin was found in oven dried material kept in airtight container (6.13%) (Fig. 14). Moisture content was significantly affected due to storage periods. The moisture content in fleshy root powder was higher when atmospheric moisture was high. Powder kept in open container was more prone to moisture absorption compared to airtight container. The lowest moisture content was observed in oven dried powder kept in airtight container (6.79%).

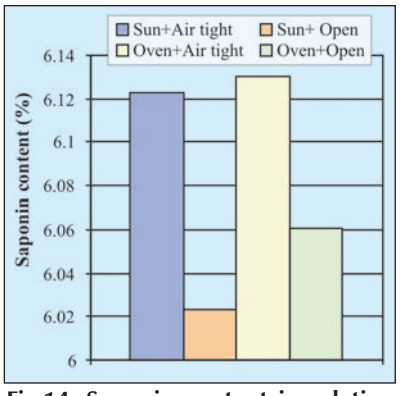


Fig.14. Saponin content in relation to storage of safed musli at Akola.

SANKHPUSHPI (*Convolvulus microphyllus*)

Sankhpushpi is a *medhya* drug, which contributes considerably to the improvement of the memory power and intellect. The whole plant possess medicinal properties. It belongs to the family Convolvulaceae and the alkaloids present in the herb is therapeutically important. Study on floral diversity revealed that it included plants of different flower types.

Study of population and breeding behaviour

At NRCMAP, study on variation in plant types, corolla type and petal colour was conducted. Also the reproductive biology including the breeding behaviour of the species was studied.

Floral measurements

Results revealed that diameter of flower ranged between 10.75 and 17.5 mm, length of peduncle between 0.00 and 25.59 mm, length of pedicel between 0.35 and 3.56 mm, length of sepals between 3.18 and 6.52 mm, corolla between 7.73 and 13.37, stigma length between 2.77 and 6.43 mm, style length between 1.07 and 3.17 mm, length of anthers between 0.87 and 2.21 mm and filament length between 1.08 to 6.56 mm in the population.

Distribution of different polymorphic plant types in population

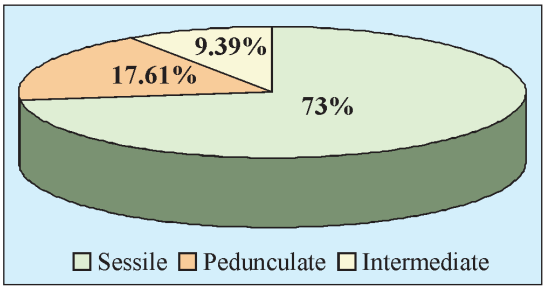


Fig. 15. Distribution of plants types in population at NRCMAP.

In the population, three plant types were identified based on nature of inflorescence i.e., plants with either pedunculate (pedunculate type) or sessile inflorescence (sessile type) or plants with both pedunculate and sessile inflorescence (intermediate type). Sessile plants were distributed maximum in the population (73.00%), followed by pedunculate (17.61%) (Fig. 15). Intermediate types were distributed minimum in the population (9.39%). The study was conducted by dividing the whole plot (~ 20 ha) into four subplots.

In the subplots also sessile plant types were distributed maximum (%) i.e., 81.99, 75.56, 71.76 and 64.46 in subplots 1,2,3 and 4, respectively. Pedunculate plant types were in the frequency of 13.81, 20.16, 17.06 and 19.01 respectively in subplots 1, 2, 3 and 4. Intermediate plant types were distributed minimum i.e. 4.2, 4.28, 11.18 and 16.53 respectively in the subplots 1, 2, 3 and 4.

Polymorphism in terms of flower colour also was recorded. About 1344 plants of the population were studied for flower colour. Three distinct colour types were recorded. Light pink was distributed maximum (57.37%) in the population, which

was followed by white flower (36.53%), while pink flower was distributed in a very low frequency (6.10%).

The same trend was also observed in the three plant types. In pedunculate type, light pink was distributed in a frequency (%) of 61.51, while it was 55.10 in sessile and 64.94 in intermediate type. Distribution of white flower colour in pedunculate, sessile and intermediate plant types varied as 31.38, 39.33 and 27.27 percent, respectively.

In subplots also light pink was distributed in maximum frequency (60.35, 59.88 and 54.88) followed by white (32.90, 37.79 and 38.57). Pink coloured flowers were distributed in the subplots in the frequencies of 6.75, 2.33 and 6.59, respectively.

Study of floral types

Eight different types of corolla shape were observed in the population namely mucrunate, acute between, acute, retuse, obtuse, serrated, semi-gamopetalous and corolla with fused base. Mucrunate (A) was the typical type described in the species and it was present in 10.62 per cent of the population. Acute (B) was present in 27.57 per cent of the population and acute between (C) which was having corolla character of mucrunate and acute was present in 28.02 per cent. Retuse corolla was present in 26.80 and obtuse was in 5.77 percent. Semi gamopetalous, flowers having petal fused only at the base and serrated types were very rare in the population (0.97 %, 0.10% and 0.15%). Same trend was followed in the sub plots also, however, fused base corolla type was present only in plot 1 and serrated type was observed only in plot 4.

Distribution of corolla types within different plant types

Acute corolla type was distributed maximum within pedunculate type (34.49 %) whereas, retuse type was observed maximum within sessile plant types (30.34%). However, within the intermediate type, acute corolla type was found maximum (27.72%).

Floral study

Result of measurements of different floral parts *viz.*, length of the peduncle, pedicel, outer sepals and inner sepals, corolla, stigma, style, anther, filament, diameter of ovary, etc., revealed that mean values of the measurements of above said floral parts varied greatly within and intra class. Significant difference in diameter of flower (rangeed from 10.75 mm to 17.5 mm) was observed while length of peduncle and pedicel ranged from 1.09 to 15.59 mm and 0.35 to 3.56 mm, respectively. Sepals and corolla length showed variation ranging from 3.18 to 9.52 mm and 7.73 to 13.37 mm, respectively.

Chemical finger printing was carried out to know the chemical variation within the species and also attempt was made to distinguish the plant type with the help of chemical finger printing data. Results showed that in chemical fingerprint, 11 bands appeared in HPTLC plates of different plant types collected from four subplots. However, band specificity to particular plant types was not detected. The concentration of individual constituents varied among the plant types.

Time of anthesis and pollen dispersal

Time of anthesis varied in the population. In cooler months like December, January and February, anthesis was initiated comparatively late (between 8.30 to 8.45 am) and completed within 1 to 1.30 hours. However, anthesis initiation was recorded at ~7.00 a.m. in March and at ~6.30 a.m. in the month of April because of early sunrise and increase in atmospheric temperature. The entire process of anthesis was completed within 30 minutes. Irrespective of the anthesis time, anther dehiscence occurred along with anthesis, however, pollen dispersal took about 1.00 to 1.30 hrs after initiation of anthesis in cooler months and in March and April it took only 15-30 minutes. However, flowers closed within 5-6 hours after anthesis during those months.

Study of floral visitors

Observations were made on insect visits to the open flowers. Result showed that there were frequent visits by a number of insects. Insects collected revealed that about five types of insect were very common and they were Indian rock bee (*Apis dorsata*; Family: Apidae; Order: Hymenoptera), Italian bee (*A. melifera*; Family: Apidae; Order: Hymenoptera), Shield bug, House fly (*Musea domestica* Family: Muscidea; Order: Diptera) and Grasshopper

Study of pollen grains

Pollen grain size was measured by collecting pollens from different floral types. The size ranged from 29.04 to 33.2 µm. in sessile plants. In pedunculate flowers, the size of pollen grains ranged from 28.7 to 31.4 µm. Ornamentation of pollen surface sculpture was of reticulate type. Pollen type was trizonocolpate and heteropolar. Shape of the pollen was spherical to quadrangular.

Brew Baker medium with 30 per cent sucrose was used for pollen germination. Maximum pollen germination (56.25%) was obtained at room temperature (28± 2°C). Pollen bursting was recorded maximum in 2-10 per cent sucrose concentration, in liquid medium. In solid medium, 25 per cent sucrose showed maximum pollen germination (36.63%), however, germination percentage was lower in comparison to those of 30 per cent liquid medium.

Pollen grains collected on the same day and stored at room temperature in humidity chamber showed germination up to 16 hours, while in refrigerated condition it remained even after 28 hrs of storage. At 9.30 am, pollen germination was recorded highest (56.25%).

Acetocarmine test showed about 83.6 percent pollen staining in the species. Fluorochrome Reaction (FCR) test revealed 81.47 percent viable pollen grains.

Study of stigma receptivity

Emasculated pistils were uniformly pollinated from 8.00 am to 4.00 pm at 2-hour interval. Data on fluorescence study revealed that pollen tube growth on pistils pollinated at 10.00 am to 4.00 pm. There was no pollen tube growth in pistils pollinated at 8.00 am. However, maximum pollen growth was found in pistils that were pollinated at 11.00 am.

Pollination experiments

Eight different pollination methods viz. selfing by bagging, self pollination between two flowers of the same plant (geitenogamy), self pollination within the flower, cross pollination in sessiele plant types, cross pollination in pedunculate plant types, cross-pollinationn between pedunculate and sessile plant types, cross-pollination between sessile and pedunculate plant types and open pollination were tried at NRCMAP (Fig. 16).There was no or very few pollen tube growth in pistils collected from the self-pollination treatments where the pollination successes varied from 0.0 to 15.0 per cent only.

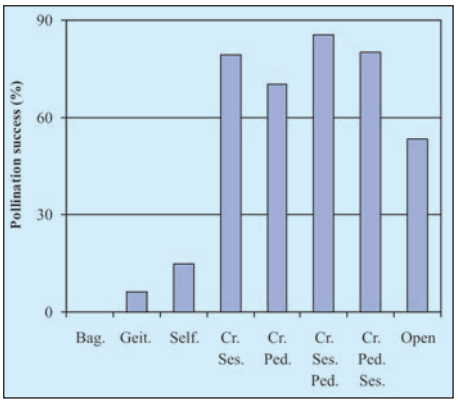


Fig. 16. Pollination success in different pollination treatments at NRCMAP

In cross-pollinated treatment, higher percentage of pollen tube growth was observed (70 to 85.29% pollination success) (Fig. 16). In open pollinated pistils, pollination success was recorded up to 53.33 per cent. Stigmatic pollen ovule ratio was also highest in cross-pollinations (3.69 to 7.27) and lower in self-pollinations (0.0 to 0.65). In open pollination, it was 2.11 only.

In vitro pollen tube growth was also recorded higher in all the cross-pollinations and open pollination and it was almost nil in selfed pistils. The experiment revealed the cross pollinating nature of the species.

TINOSPORA (*Tinospora cordifolia*)

It belongs to the family Menispermaceae. The mature stem is acrid, bitter, hot, restorative, aphrodisiac and used as a digestive tonic. In India it is distributed almost throughout extending from Himalayas down to Southern part of Peninsular India. At NRCMAP, a study was conducted to find out differences among the male and female plants of the species within the available germplasm. Floral biology of the species was also conducted.

Morphological study

Polymorphism in leaf shape was very much pronounced in the population of Tinospora. Different leaf shapes could be identified based on the shapes of leaf base and leaf apex within the same plant accessions and also in population. Leaf base also varied from cordate, subcordate or deeply cordate or truncate and leaf apex varied from obtuse, mucronulate or apiculate in the population.

Leaf length and breadth (l/b) ratio of male plants ranged from 0.86-1.25 and in females it was 0.82-1.25.The highest l/b ratio was observed in IC-310608 accession and lowest was recorded in NRCTC-3 and NRCTC-6 among the male

plant collections. In female plants, it was highest in NMRM-13 and lowest in IC- 310621 accessions.

Diameter of the stem varied at the stem base ranging from 1.60-20.50 mm and it was 1.22 to 12.66 mm at 30 cm above the base in the male accessions. In females, stem base diameter was 2.70 to 16.04 mm at the base and 2.75 to 13.00 mm at 30 cm above the base level.

The length of male inflorescence ranged from 3.00 to 13.50 cm. In male flowers, number of stamens varied from 5-8. Diameter of male flowers of different accessions ranged from 4.50-6.52 mm; length of sepal was 3.86± 0.53 mm, breadth of calyx 2.46± 0.50 mm; length of petal 2.10 ± 0.26 mm and length of stamen 3.24 ± 0.53.Meiotic study conducted in microspore mother cells, showed 13 bivalents at meiotic metaphase I.

Phenology

Flowering phenology was studied from the month of December to April and it was found that males were in full bloom in December, however, females were not in flowering during this month. In January, females started flowering till I week of April. Female bloom was staggered in nature i.e. female blooming was not simultaneous and there was time gap between two female blooms during the season. However, male flowering was present through out the season. Comparing to males, females were shy in flowering.

Fig. 17. Staminate inflorescence along with fruits in Tinospora at NRCMAP

Appearance of female phase in male flowers (Fig. 17) was observed in the population. This temporary expression of gynodioecy in *T. cordifolia* was not reported in the species earlier. The phenomenon was not a rule in the population. In the earlier part of this conversion to hermaphrodism, small protuberance appeared in the centre of male and later it was converted to fully developed pistils. There were three pistils, but fruit setting was not successful in all these hermaphrodites. It was observed that one or two fruit/s was/ were developed normally in a hermaphrodite. However, fruit setting success in the normal female flower was almost 100%.

Anthesis

Anthesis pattern of male and female flowers was studied in the months of January and February, for a duration of 12 hours and again in the second week of April, for 24 hrs duration. During the 12 hrs of observations in January and February, maximum anthesis occurred from 12.00 noon to 4.00 pm in both male and female plants. In the month of April, maximum anthesis was during 12.00 noon to 2.00 pm (75%) in both male and female plants. There was no anthesis during 12.00 midnight to 12.00 noon. These observations showed that anthesis in the species is a continuous process distributed in a period of 24 hours and maximum anthesis was in the afternoon i.e. 12.00 noon to 4.00 pm.

In males, time duration for the initial bud to reach mature bud stage was 35-45 days. Anthesis in matured male inflorescences was comparatively slower and took about 2-3 days. Anthesis was very slow and it took about 2-4 hrs from anthesis initiation in the mature bud to complete anthesis. In the bud stage, flower was completely surrounded by calyx and anthesis occurred by splitting of the sepals of the calyx in the longitudinal direction. Freshly opened males produced fragrance and a number of floral insect visitors were observed visiting the flowers. The flower remained fresh in the plant for about 2-4 days and then started to wither.

In female plants, time duration for the initial young bud to reach fully matured bud stage was about 25-35 days. Anthesis in matured female inflorescences was comparatively faster and completed within a day. Anthesis was also comparatively faster and the process was completed within an hour. Calyx withered within 4-7 days and from bud to fruit maturation, it took about 50-60 days. Stigma was found to be of sticky nature in freshly opened flowers. Average number of fruits developed from a single flower was 3-4.

Pollen dispersal

Anther dehiscence started at the time of anthesis, but the pollens were clumped together at this stage. Pollen dispersal started after about 6 hrs of anthesis and became powdery, which helped pollen to transfer through air. The study indicated that pollen transfer in the species is through wind and the species is anemophilous type.

Floral visitors

Floral visitors identified were aphids and black ant (*Dolichoderus* spp.). However, it was observed that the insects were attracted only to the males and there were no floral visitors nearby female flowers. Hence it was inferred that the insects were not having any role in pollination in the species and were supposed to be pollen eaters.

Pollen study

Different sucrose concentrations were tested in the Brew Baker's medium. The experiment was conducted in the month of February. Maximum germination percent was recorded in five per cent sugar concentration of Brew Baker's medium. The same trend was also obtained in the month of April, but germination per cent was comparatively higher.

Pollen grains tested by acetocarmine gave 80.41 ± 2.97 percent staining and FCR (fluorochrome reaction) test revealed 69.45 ± 2.07 percent viability.

Pollen germination was studied in pollens collected at different anthesis time. Flowers opened at 6.00 pm gave maximum germination (69.09%). Pollen germination was studied in pollens stored at different storage duration in room temperature (29.6 ± 4°C) and at 4°C. Results showed that pollen germination was 45.42 and 35.00 per cent after 2 hrs of storage under room temperature as well as at 4°C, respectively. Pollen germinability was completely lost after about 6 hrs of storage under both the conditions.

Study of starch

Iodine test in hand sections of stems was carried out in both male and female accessions. Starch deposit was found in the cells of cortex, endodermis, medullary rays and pith of the stem. There was no specific pattern related to gender of the plant, however, different types of starch accumulation were present in different female and male accessions**.** IC 285624- a female accession showed practically very little starch granules in the stained sections.

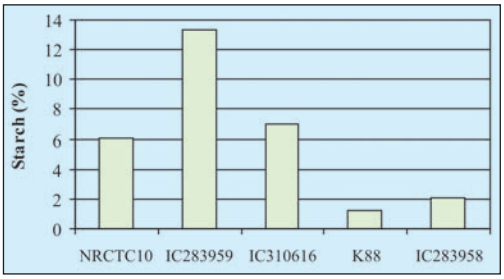


Fig 18. Starch content in male accessions of Tinospora at NRCMAP

Shape of starch granules varied greatly from round, dumbbell, cylindrical, cylindrical with concave and convex surfaces, triangular to different non-specific shapes. Starch granular size also varied within and between the accessions. Smallest starch granules were recorded in IC 285624 accession. Study of starch content showed that starch content varied greatly among different lines of male and females and the difference was not specific to sex. Among males (Fig. 18), maximum starch content was in IC 283959 (13.32 %) and minimum in K 88 (1.22%).

Study of chemical finger printing

Results of chemical fingerprinting of leaf and stem of five each of male and female accessions showed the presence of seven bands in leaf and nine bands in stem. However, no specific band differentiation could be observed in male and female plants**.**

AROMATIC PLANTS

LEMONGRASS (*Cymbopogon flexuosus*)

The perennial grass belongs to the family Poaceae. It is an aromatic plant and owes its name to the strong lemon like aroma of the essential oil derived from the leaf. It is cultivated for its essential oil, and is extensively used in perfumery, flavouring and medicine. It also has antibacterial properties. The species is considered to have originated in India. Warm humid climate favours better plant growth.

Evaluation of germplasm

Twenty one genotypes of lemongrass planted in August, 2003 were harvested three times and mean data of three cuts were recorded at Hisar. Plant height (cm) ranged from 82.38 (HL-8) to 122.12 (RRL-82), tillers per plant from 31.78 (NLG-118) to 97.33 (CKP-25), leaf length (cm) from 50.17 cm (HL-8) to 85.00 cm (OD-23), leaf width from 0.82 cm (RRL-82) to 1.88 cm (HL-1), fresh herb yield per plant ranged from 540.33 g (NLG-118) to 1174.31 g (HL-10), oil percent

from 0.27% (HL-1) to 0.81% (CKP-25) and oil yield per plant ranged from 1.75 ml (HL-2) to 6.54 ml (CKP-25). The genotype HL-10 recorded highest herb yield per plant (1174.31 g) followed by HL-9 (1136.09 g), HL-5 (1085.28 g) against best check OD-58 (1084.23 g). The genotype CKP-25 recorded highest oil content of 0.81% and oil yield of 6.54 ml plant^{-1}.

Influence of nitrogen on growth and yield of different genotypes

Effect of nitrogen on four genotypes (CKP-25, OD-19, LS-1 and LS-3) was studied at NRCMAP. Three levels of nitrogen (0, 100 and 200 kg ha^{-1}) were taken for the study. Application of nitrogen significantly increased yield and yield attributing characters. Herbage yield was significantly maximum (4223 kg ha^{-1}) with application of 200 kg ha^{-1} of N. The same treatment also produced highest oil yield (176.75 kg ha^{-1}). Lowest herbage and oil yields were recorded in the control (2970 and 123.15 kg ha^{-1}, respectively). The genotypes registered significant differences in growth and yield except plant height. CKP-25 produced highest number of tillers (37.04 clump^{-1}) and consequently produced maximum number of leaves (292.87 clump^{-1}) compared to other genotypes. However, herbage (44.81 tonnes ha^{-1}) and oil (205 kg ha^{-1}) yield was found to be highest in LS-1.

Effect of organic and inorganic nutrients on herbage and oil yield

A field experiment was conducted at NRCMAP to see the effect of FYM and inorganic nitrogen on yield. Three levels of FYM (0, 5 and 10 tonnes ha^{-1}) and inorganic nitrogen (0, 75 and 150 kg ha^{-1}) were tested on the cultivar OD-19. Application of manure did not show significant impact on growth and yield. However, inorganic nitrogen had significant effect on yield attributing characters and yield. Application of N at150 kg ha^{-1} produced significantly highest number of leaves clump^{-1} (138.17). Significantly maximum herbage (3594 kg ha^{-1}) and oil (99.16 kg ha^{-1}) yield were also recorded with 150 kg N ha^{-1}. The treatment could increase the oil yield by 26.71% over control (78.26 kg ha^{-1}).

PALMAROSA (*Cymbopogon martinii*)

It is an important aromatic plant cultivated for its essential oils extracted from floral shoots and aerial parts. It belongs to the family Poaceae and its oil rich in geraniol is used in perfumery and aromatherapy and is also a starting material for a large number of synthetic aroma chemicals. Palmarosa is a tall perennial tufted hedge, native of most parts of subtropical India.

Evaluation of germplasm

Sixty four clonal selections were evaluated at Hisar for various morphological characters based on mean value of three harvests (cut). Plant height ranged from 174.67 cm (RH-03-20) to 238.33 cm (RH-03-37), number of inter node from 9.33 (RH-03-33) to 16.50 (RH-03-64), internode length from 12.00 cm (RH-03-67) to 22.67 cm (RH-03-61), flag leaf length from 9.00 cm (RH-03-60) to 20.33 cm

(RH-03-64), flag leaf width from 1.0 cm to 2.2 cm, leaf blade length from 17.00 cm to 33.33 cm, leaf blade width from 1.6 cm to 2.9 cm, number of tillers per plant from 24.33 to 136.00, inflorescence bearing tillers from 10.67 to 117.00, panicle length from 36.00 cm to 87.33 cm and number of panicles per plant from 6.67 to 14.67. Fresh herb yield per plant was highest in RH-03-67 (2.488 kg) and the lowest in RH-03-47 (0.156 kg). Oil content on fresh weight basis (FWB) ranged from 0.25 (RH-03-38) to 0.60 percent (RH-03-29). Computed oil yield per plant ranged from 1.5 ml plant^{-1} (RH-03-47) to 10.7 ml plant^{-1} (RH-03-67). Geraniol content ranged from 9.90 percent to 82.50 percent. Geranyl acetate content ranged from 1.10 to 10.76 percent.

Integrated nutrient management

An attempt was made at NRCMAP to study the effect of organic manure and nitrogen alone and in combinations on growth and yield performance. Organic manure was applied in the form of FYM @ 0, 5 and 10 tonnes ha^{-1}, while inorganic N application was applied @ 0, 75 and 150 kg ha^{-1}. Application of FYM did not show significant difference in respect of growth, yield and quality parameters. However, inorganic N significantly influenced the yield and yield attributing characters studied. Number of tillers (54.84) and inflorescence (19.71) clump^{-1} were highest with 150 kg ha^{-1} N. Inflorescence length also increased significantly with nitrogen (27.58 and 27.89 cm) over control (25.95 cm). The maximum herbage (4769 kg ha^{-1}) and oil yield (241.39 kg ha^{-1}) were recorded with 150 kg N ha^{-1} whereas, control recorded minimum herbage (3810 kg ha^{-1}) and oil (182.70 kg ha^{-1}) yields (Fig). The geraniol content in the oil ranged between 70.33-72.94 % while geraniol acetate varied from 15.73-19.00 %, all being at par.

INFORMATION MANAGEMENT (ARIS)

Institute Inward Outward Letter Monitoring System

ARIS cell has developed a software package entitled "Institute Inward Outward Letter Monitoring System" (IIOLMS) for monitoring letters received by the institute and thereafter marked to different employees for taking action. In most of the cases, it is very difficult to keep track of such letters once it is marked, unless the person to whom it was marked reports back. To over come this situation, ARIS cell has developed this software by which track on letters can be kept and therefore monitoring can easily be done. It would rather precisely facilitate to keep track on persons to whom a letter is marked and thereby mandatory action from that person can be firmly expected within a time frame.

The software package consists of four options i.e. 'Institute entry', 'Employee entry", 'Inward & outward entry' and 'Reports'. The first option 'Institute entry' allows the user to enter the institute details such as Institute Name, Acronym of the institute, address of the institute etc.

The second option 'Employee entry' provides the sub window having command buttons namely "Add Record" and "Edit Record". Add Record allows entering the details of the employees such as employee number, name, designation, department, phone, email etc in to the database, and Edit Record allows to edit existing employee details.

The third option 'Inward Outward Entry' deals with the monitoring of letters received and marked to different employees for taking action. This option provides the sub window having command buttons namely "Add Record", "Edit Record" and "Add Reply". The sub window option "Add Record" allows to enter the details of the letter inward details such as inward no, letter received date, letter no, subject, from address and to whom letter marked etc (Fig. 19). The next sub window option "Edit Record" allows modifying the existing record details. The next sub window option "Add reply" allows to enter the details of replied letter such as whether the reply has been sent or not, replied date etc.

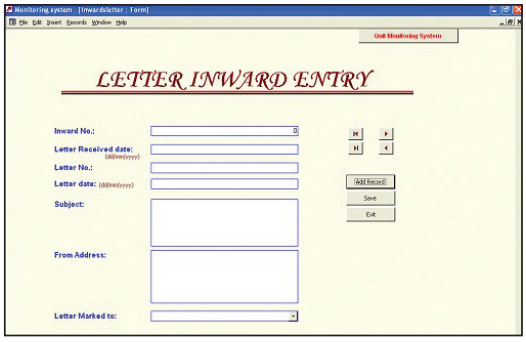


Fig. 19.Window for adding inward letter details

The fourth option 'Reports' provides preview reports, print reports which consists of non action taken reports and action taken reports in the pre defined formats such as "Selective Employee wise", "All employee wise", "Selective date and employee wise", "Selective date and all employee wise", "Selective period and employee wise", "Selective period and all employees wise" (Fig. 20). By following the instructions, the selected predefined report gives the required report.

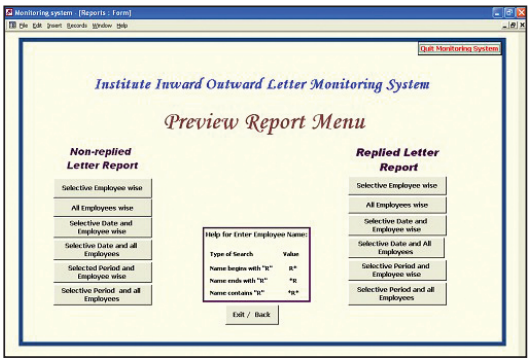


Fig. 20.Window for reports menu

The IIOLMS has a number of advantages such as user-friendly package, simple to operate, maintainable database, trouble-free generation of reports and uncomplicated prints.

Development of IIOLMS" (Ver. 1.0) CD

ARIS cell has designed and developed a first version of compact disk entitled "Institute Inward Outward Letter Monitoring System (IIOLMS)" for monitoring of letters received by the institute and marked to different employees for taking action. Several copies of the CD have already been distributed to different ICAR institutions and resources generated through this distribution.

Development of digital photo library of medicinal plants (Part-1)

ARIS cell has designed and developed a first version of compact disk entitled "Digital photo library of medicinal and aromatic plants". Honorable Vice Chancellor Prof. S.L. Mehta, MPUAT, Udaipur released this CD in the 15th group meeting of AINP on MAP held at MPUAT, Udaipur during 11-14th December, 2004.

The first version of this CD has 100 digitalized photographs of various aspects of medicinal and aromatic plant species in the format of photo album as well as in the software package.

Digital photo library of medicinal and aromatic plants is a collection of photographs of high resolution. The CD was developed to remove confusion and ambiguity in the identification of medicinal and aromatic plant species by common man.

Databases

During the year, attempts have been continued for updating the databases like Medicinal and Aromatic plants References Information System, Traders Information system on Medicinal and Aromatic plants, Website of NRCMAP, Digital Photo Library of Medicinal & Aromatic Plants, and Digital Herbarium of Medicinal Plants in India.

All India Networking Project on Betelvine

All India Networking Project on Betelvine is in operation in ten centres. Eight of these centres are in operation in various state agricultural universities and one in IIHR, Bangalore. A new centre is working at RAU, Islampur, Bihar on production technology of Mahai pan. The new centre at CHES (IIHR), Chetali is working on betelvine germplasm conservation and breeding of betelvine. A multidisciplinary team of about 23 scientists of various disciplines such as Plant Breeding, Agronomy, Horticulture, Plant Pathology and Entomology were working in research on various aspects of Crop Improvement, Crop Production, Crop Protection, Post Harvest Physiology, etc. Emphasis was given for development of efficient water management strategies by using drip irrigation and IPM for major insect pests and diseases. In the year under report, two multi-location experiments in crop improvement, five in crop production, four in plant diseases and seven in insect pests and mites were carried out. Two station trials were also carried out. Results of various experiments are presented in this annual report.

Germplasm collection, maintenance and evaluation

Germplasm maintained and catalogued in different centres are as follows:

Centers	Total collections	Maintained	Catalogued
AAU, Jorhat	14	14	11
ANGRAU, Bapatla	51	51	51
BCKV, Kalyani	39	32	32
JNKVV, Jabalpur	29	29	23
MPKV, Sangli	28	28	28
OUAT, Bhubaneswar	40	40	40
RAU, Pusa	20	20	-
TNAU, Sirugamani	45	45	45

The germplasms were evaluated for their leaf and vine growth characters, resistance to pest and diseases, keeping quality and organoleptic properties.

Hybrid evaluation trial

Four hybrids (GN1, P1, P2 and GB) were tested for their performance under the field conditions at MPKV, TNAU and BCKV centres. The results showed that only GN 1 hybrid (Gach pan x Kapoori Nasik) showed hybrid vigour in TNAU out of four hybrids tested. GN1 hybrid expressed hybrid vigour and was found to be promising with large Bangla leaves in the primaries and narrow karpoori leaves in the laterals. GN1 produced marketable leaves of 20.53 lakh ha^{-1} weighing about 252.30 g 100 $leaves^{-1}$. The other 3 hybrids, P_1, P_2, and GB (OP) expressed hybrid depression and produced unmarketable leaves of poor quality thus not suited for cultivation. GN1 hybrid will be tested in the farmers holding for its adaptability.

Among the four hybrids evaluated at MPKV, hybrid GN_1 was found to be promising with large leaves. GN_1 hybrid produced 14.09 lakh ha^{-1} marketable leaves with about 220 g per100 leaves. The other three hybrids P_1, P_2 and GB expressed hybrid depression. The survival percentage is very less. However, all the hybrids were inferior in all the growth and yield parameters as compared with local check (Kapoori.). The hybrids did not survive at BCKV centre.

Efficacy of bio-fertilizers

Various bio fertilizers like azotobacter, phosphobacter and azosprillum were applied in combination with other organic manures like vermicompost and inorganic fertilizers to study the efficacy of bio-fertilizers on growth, yield, shelf life and organoleptic quality of betelvine. Two levels of azotobacter (5kg & 10kg), azotobacter 5kg + Phosphobacter, Vermicompost and MOC+Urea (1:1) were applied in combination with NPK to betelvine for their effect on vine growth, yield and keeping quality of betel leaf. At AAU, vermicompost had recorded superior fresh weight followed by MOC + urea. Vermicompost, MOC+urea and Azatobacter treated plots produced higher leaf yield compared to other treatments. The cost benefit ratio for the vermicompost was the least among the treatments.

At ANGRAU centre, application of various bio-fertilisers, organic and inorganic fertilisers did not significantly influence vine growth, leaf yield, *Phytophthora* foot rot disease incidence.At JNKVV, maximum leaf yield (33.33 lakh ha^{-1}), weight of 100 leaves (342.33 g), inter-nodal length (5.54 cm) and keeping quality (15.33 days) were observed with combination of azotobacter + phosphobactor + FYM. It was at par with oil cake +urea and vermicompost. Maximum disease incidence (16.96 %) was noted with oil cake + urea and it was minimum with azotobactor (5 kg ha^{-1}). None of the treatments provided substantial economic benefit over control

At MPKV, application of recommended dose, (200 kg N + 100 kg P_2O_5 +100 kg K_2O ha^{-1}) recorded significantly more number of branches (37.25), maximum leaf yield (68.49lakh ha^{-1}) and keeping quality of leaves (16.5 days) over all other treatments followed by application of 200 N Kg ha^{-1} + 5 kg phosphobactor + 100 kg K_2O. The maximum cost benefit ratio of 1:58 was observed with RDF.

At OUAT centre, leaf yield was observed to be significantly higher (48.25 lakh yr^{-1} ha^{-1}) with application of azotobacter 5kg ha^{-1} and phosphobacter 5kg ha^{-1} followed by vermicompost application. Longer shelf life (13.5days) was observed with application of vermicompost along with decreased organoleptic test (2.60) being statistically at par with application of azotobacter 5kg ha^{-1}. Application of

azotobacter 5kg ha^{-1} and Phosphobacter 5kg ha^{-1} also reduced significantly the leaf disease incidence with the highest cost benefit ratio of 1:3.82.

At RAU, bio-fertilizers alone or combination with inorganic fertilizers had significant effect on elongation of vine, number of consumable leaves per hectare, fresh weight of 100 leaves and leaf area of betelvine in addition to nutrient content in plants, nutrient uptake by the plants and finally soil nutrient status. Vermicompost @ 12 ton ha^{-1} significantly increased the dry biomass of the leaf. Soil application of vermicompost also had marked increase in the nitrogen nutrient content of the soil.

At TNAU centre, among the eight treatments imposed with various combinations of bio fertilizers and inorganic fertilizers in variety SGM1, the treatment containing azosprillum 5kg ha^{-1}+ 100 kg each of P_2O_5 and K_2O ha^{-1} showed better leaf yield of 43.26 lakh ha^{-1}. Shelf life was more (14.78 days) in the same treatment compared to the other treatments

Integrated crop management

A crop management comprised of 200 lakh plant population + 100% replenishment of CPE + 4 application of *Trichoderma* + 100 kg P + 100 kg K + sanitation at AAU, produced maximum leaf yield. Final soil status and uptake by leaves showed that nitrogen and phosphorus retention was at par. Uptake of nitrogen and potash was at par. It indicated the fixation of phosphorus as well as potash in the soil leading to soil build up of both the nutrients. However, potash retention was higher in plant population with combination of Bordeaux mixture. Cost benefit analysis revealed that farmers' practices produced least return in comparison to INM and IPM approach because of adopting higher plant population as well as disease, nutrient and irrigation management aspects.

At ANGRAU centre, treatment combination comprising optimum plant population (1,00,000 plants ha^{-1}), recommended fertilizers applied with neem cake + urea (1:1) at 200 kg N, 100 kg P_2O_5 and 100 kg K_2O ha^{-1}, irrigation 100% replenishment of CPE and application of Bordeaux mixture (4 drenches and 8 sprays) recorded significantly higher leaf yield of 58.93 lakh ha^{-1}as against 51.07 lakh ha^{-1}in farmer's practice.

At JNKVV, maximum vine elongation per month (15.42 cm), number of leaves (37.23 lakh ha^{-1}) and weight of 100 leaves (624.71 g) were recorded with 1.75 lakh plant population, 200kg nitrogen in 4 slits in organic form +100 kg P_2O_5 + 100 g K_2O + irrigation at 100% replenishment of CPF + Bordeaux mixture application (4D) + recommended insecticides. This treatment combination provided highest cost benefit ratio. The above treatment was at par with treatment comprising the above combination with trichoderma application and sanitation instead of BM application. The maximum disease incidence (15.50%) and minimum keeping quality (9.7 days) of leaves were observed with farmer's practice.

At MPKV centre, the application of best plant population + 200 kg nitrogen in splits in organic form + 100kg P_2O_5+ 100kg K_2O + irrigation at 100 % replenishment of CPE + 4 application of trichoderma + sanitation + recommended insecticides recorded significantly more leaf yield (66.16 lakh ha^{-1}). The differences in height of vine (3.35 m.), number of branches per vine (37.57), the fresh weight

of 100 leaves and keeping quality were found non significant. The maximum cost-benefit ratio of 1.48 was received in the above treatment. The incidence of foot rot in the farmer's practice was 25.69%.

At RAU, the applications of Trichoderma accompanied with sanitation and protecting the crop with recommended doze of insecticide was found at par with 3 drenching of Bordeaux mixture (1%) followed by 6 sprays of Bordeaux mixture (0.5%) in terms of vine growth, number of consumable leaves ha^{-1}, fresh weight of 100 leaves, shelf life, per cent disease index and biomass of leaf including dry matter yield. Other parameters like nutrient content in plants and finally nutrient status of the soil remained unaffected. However, nutrient uptake by plant was significantly higher in treatment T_1 (1.50 lakh plant ha^{-1}+ 200kg N as organic (4splits) + 100kg P_2O_5 + 100kg K_2O + irrigation at 100% replenishment of CPE + 4 applications of *Trichoderma* + sanitation + recommended insecticide) and T_2 (1.50 lakh plant ha^{-1} + 200kg N as organic (4 splits) + 100kg P_2O_5 + 100kg K_2O + irrigation at 100% replenishment of CPE + 3 drenching of Bordeaux mixture (1%) with 6 sprays of Bordeaux mixture (0.5%) + recommended insecticide if required) compared to control (Farmers' practice).

Nutrient uptake studies

Nutrient uptake studies carried out at different centres showed that the application of nitrogen in the form of FYM or oilcake equal to recommended dose of N provided better crop performance with superior betel leaf quality.

At AAU, due to quantitative variation in fertilizer doses through organic source as well as already recommended source of MoC+ Urea, significant differences were observed in leaf yield and keeping quality. At the highest doses of NPK, it was observed that FYM produced the maximum yield followed by N at same dose but in the form of MoC (mustard oil cake). When the dose was reduced to $3/4^{th}$ the yield also reduced and produced at par results with the lower doses. It was observed that whenever there was an element of urea, the keeping quality was at the lowest side due to early rotting as well as supple character of the leaf. Soil NPK status indicated that MoC at higher doses contributed significantly to soil build up of N balance than other treatments followed in similar trend by FYM at the same dose of N. Uptake studies showed that through higher doses of N, the uptake could be raised against the maximum yield by FYM. Similar results were observed in phosphorus and potash retention as well as uptake. The disease incidence was observed to be significantly higher in urea-contained treatment than the others. The cost benefit ratio showed that MoC both at 200kg or 150kg ha^{-1}, produced equal return. FYM application produced higher yield and the return was reduced due to high cost of FYM. The results of the experiment revealed that the treatment in which NPK (kg ha^{-1}) 200 [Neem cake + Urea (1:1)], 100 & 100 were found superior for vine elongation, branching, leaf yield, fresh weight of 100 leaves and comparatively lower incidence of *Phytophthora* wilt disease.

Leaf yield was recorded highest (59.11 lakh ha^{-1}) in T_2 (NPK (kg ha^{-1}): 200 (oil cake + urea): 100:100) treatment and it was statistically at par with NPK 150:50:50 kg ha^{-1} either through oilcake or oilcake + urea at BCKV centre.

At JNKVV, maximum vine elongation $month^{-1}$ (15.01 cm) was noted, where 200kg nitrogen was applied through oil cake +urea, but maximum number of

leaves (36.42 lakh ha^{-1}), weight of 100 leaves (630.75 g) and keeping quality of leaves (13.3 days) were obtained with 200kg nitrogen through FYM. It was also found that application of 200 kg nitrogen through only oil cake or oil cake + urea (1:1) were at par with 200 kg nitrogen through FYM. Maximum disease incidence (18.92 %) was observed with 200 kg nitrogen through oil cake and urea. Maximum nutrient uptake was observed where 200 kg nitrogen was applied through oil cake with the uptake of 103.25 kg N, 31.25 kg P_2 O_5 and 50.25 kg K_2O.

At MPKV, application of NPK (kg ha^{-1}) 200 (FYM): 100: 100 recorded significantly more leaf yield (61.84 lakh ha^{-1}.) followed by NPK (kg ha^{-1}): 200 (oil cake): 100: 100 (55.59 lakh ha^{-1}). The maximum cost benefit ratio of 1:1.45 was observed in former treatment, which retained higher organic carbon in soil. Similar trend was also observed in respect of available N, however, it was at par with application of NPK (kg ha^{-1}): 150 (FYM): 50: 50.

At OUAT, application of recommended fertilizer dose i.e. NPK (kg ha^{-1}) 150 (oil cake + urea): 100:125 significantly increased leaf yield (49.75 lakh ha^{-1}) whereas application of oil cake as sole nitrogen source (150kg N ha^{-1}) along with P_2O_5 and K_2O produced the second highest yield of 45.26 lakh ha^{-1} with comparatively larger leaves (15.35 x 12.50cm). Significantly maximum fresh weight of 100 leaves (292.80g), longer shelf life (13.75days) and highest organoleptic test (3.25) was recorded in the treatment with application of mustard oil cake as sole nitrogenous source along with P_2O_5 and K_2O .The treatment also remained at par with application of FYM (150 kg ha^{-1}) with P_2O_5 and K_2O and oil cake (100kg ha^{-1}) with P_2O_5 (50kg ha^{-1}) and K_2O (62.5 kg ha^{-1}). Leaf disease incidence was significantly lowest (8.50%) with application of oil cake (150kg N ha^{-1}) along with P_2O_5 (100kg ha^{-1}) and K_2O (125kg ha^{-1}).

The test results of chemical analysis of soil and whole plant including the harvested leaves after the end of the experiment (before lowering) revealed that N content of the soil was maximum with the application of recommended dose of fertilizer i.e. NPK (kg ha^{-1}) 150 (Oilcake + Urea): 100:125. P content of the soil was maximum with application of NPK (kg ha^{-1}) 100 (oilcake + urea): 50: 62.5. Highest organic carbon (0.78%) of the soil and higher K content of the leaf (1.43%) were also reported in the same treatment 2 indicating the continuous response of nutrients for the vine growth.

At RAU centre, recommended dose of NPK @ 200 kg N, 100 kg P_2O_5 and 100 kg K_2O per hectare was found significantly superior than the reduced dose (150 kg N, 50 kg P_2O_5 and 50 kg K_2O ha^{-1}) either applied in form of organic or inorganic fertilizer in the ratio of 1: 1. The higher dose of NPK was found significantly superior in respect of increase in the growth parameters such as elongation of vine, marketable leaves, dry matters of the crop and biomass of leaves. Shelf life of leaf was significantly higher in control plot and as high as upto 17 days. At the same time the control plot registered 8.82 % of PDI and as such significantly suppressed the disease severity. Similarly higher dose of NPK significantly increased nutrient content of plant, nutrient uptake by plants and finally soil status in terms of N, P_2O_5 and K_2O. Higher dose of NPK either applied in the form of oil cake or FYM were found at par with each other in these parameters.

At TNAU centre, the treatment consisting of N in the from of FYM equivalent to 150 kg and 50 kg P_2O: 50 K kg ha^{-1} recorded the highest leaf yield of 32.13 lakh leaves ha^{-1}.

Assessment of optimum level of organic carbon content

The balance of organic carbon in the soil is of pivotal importance in maintaining soil properties and dynamics of soil micro flora in the betelvine cropping system. Assessment of organic carbon content in the soil is carried out to find out the optimum level for sustainable cultivation of betelvine in various regions of our country where betelvine is cultivated commercially.

At AAU, the results of roving survey at eight places of betelvine soil revealed that though there was considerable differences in cultural practices of betelvine crop depending upon the type of cultivation such as closed, semi closed and open system, the organic carbon content did not very much. The soil content of organic carbon ranged between 0.68 to 0.78 percent in the tested soils. However, the areas where organic farming is practised the organic carbon content seemed to be at medium range, specially the closed system contained more amount of organic carbon as reflected in the last year's surveyed gardens. The results showed that the organic carbon content ranged from 0.56 to 0.78% with an average of 0.69% in the nine-betelvine fields tested.

The survey was conducted at Karimpur, Dist. Nadia during the month of February 2005. During the survey period, crop characteristics, soil characteristics, fertilizer application and disease and pest infestation were recorded from 9 farmers field and soil samples were collected from those barejas for analysis as per schedule. The farmers of Karimpur preferred to grow Bangla and Deshi Bangla. Some farmers also grew Vera Pan, Guashi Pan etc. They harvested (leaves $month^{-1}$) 10000 to 12000 leaves. Internodal length ranged from 6.0-10.0 cm and fresh weight of 100 leaves ranging from 320-610 g. The results of soil analysis showed that organic carbon (%) content, total N (%), total P_2O_5 kg ha^{-1} and total K_2O kg ha^{-1} ranged from 0.39-1.82%, 0.14- 0.126%, 625.9-1153.9 kg ha^{-1} and 11300-16600 kg ha^{-1} respectively. The pH of the soil ranged from 7.79 to7.95.

Ten soil samples were collected from three betelvine growing areas near Jabalpur to assess the optimum level of organic carbon content in Betelvine cultivation. It was found that soil application of 255 kg nitrogen in the form of oil cake and urea to betelvine and soil organic carbon content of 1.3% resulted in betel leaf yield of 46.25-lakh ha^{-1} in a betelvine garden. In another farm, lesser leaf yield of 18.17 lakh ha^{-1} was obtained where 200 Kg nitrogen in the form of oil cake and urea was applied. The soil contained only 0.6% organic carbon.

The survey by MPKV at ten betelvine gardens two months after lowering and at last picking of leaves revealed that the initial organic carbon content ranged from 0.48% to 0.93% with an average of 0.68% and final average of 0.78%. Betelvine crop, which received 585 kg ha^{-1} nitrogen through FYM and oil cake in which maximum organic carbon content of soil remained 1.10 got maximum leaf yield of 95 lakh ha^{-1}. In another farm where the crop received 320 kg ha^{-1} of nitrogen through FYM and oil cake and organic carbon content of 0.89 gave leaf yield of 39.00 lakh ha^{-1}. The results showed the beneficial effect of nitrogen through organic manures and the positive effect of soil organic matter.

At Poigaiputhur, Thanneerpalli, survey done at ten different adopted farmers field by TNAU center revealed that in betelvine cultivar *viz*., Dindigul (SPb-12), there was no direct influence of soil organic carbon on leaf yield and other plant characters.

Efficacy of BD (Bio-dynamics) + EM (Effective micro-organism)

At JNKVV, it was found that application of recommended dose of fertilizers was at par with EM + FYM and BD + EM + FYM. There was no significant effect of BD in cultivation of Betel vine.

At RAU, all the treatments irrespective of bio-dynamics and 100 kg N ha^{-1} through FYM, Azotobactor 5 kg + PSB 5 kg with N @ 100 kg through FYM, BD + EM + 100 kg N (FYM) and recommended dose of NPK @ 200: 100: 100 kg ha^{-1} applied in inorganic form were significantly superior as compared to T_4 i.e. 100 kg N ha^{-1} as FYM only on vine elongation and productivity of consumable leaves per hectare. However, treatment T_3 (BD + EM + 100 kg N ha^{-1} as FYM) had profound effect on nutrient content of plant, nutrient uptake by plants and finally nutrient status of the soil.

Biological control of Phytophthora foot rot

Phytophthora foot rot is an important disease, which causes considerable loss to betelvine plantations. Application of biocontrol agents positively controlled the spread of the disease and reduced the loss to betelvine crop. At OUAT, the effectiveness of single and double applications of the bio-control agent *P. fluorescens* was observed to be statistically superior in the later on the incidence of both leaf and vine rot diseases under 'Baraja' condition and also revealed a positive role of the bio-control agent in comparison to the untreated control. Highest leaf yield (46.75 lakh ha^{-1} yr^{-1}) was recorded where 4 drenching and 8 sprayings with B.M at 1.0 and 0.5 percent respectively were applied during the period of experimentation followed by the treatment with four split applications with T. *viride* (43.8 lakh ha^{-1} y^{-1}) and *Pseudomonas fluorescens* (41.65 lakh ha^{-1} yr^{-1}). Twice and four times application of *Pseudomonas fluorescens* exhibited a significant difference among the treatments as well as with the rest of the treatments particularly over control in mean leaf yield but failed to influence much to the farmers economy with respect to benefit cost ratio. The benefit cost ratio among the treatment combinations was observed to be maximum (1:4.25) where Bordeaux mixture was applied both as soil drenching and foliar sprayings closely followed by the treatment with four applications of *Trichoderma viride* (1:3.95) and *Pseudomonas fluorescens* (1:3.70).

From the above results, it can be concluded that application of Bordeaux mixture is the best among all the treatments in minimizing the disease intensity of both leaf and vine rot disease caused by *Phytophthora* sp. while the use of bio control agents can act as ecofriendly and safer substitute that can not only bring down the disease intensity, but also can give a substantial higher leaf yield with an increase in fresh weight of 100 leaves of betelvine and can be integrated suitably with both chemical and cultural methods for profitable and sustainable betelvine cultivation with increased productivity.

Epidemiological studies of leaf and vine rot disease caused by *Phytophthora sp*.

Phytophthora stem and leaf rots

Results at ANGRAU, for simple correlation between percent disease incidence (PDI) and weather parameters indicated that the disease incidence had a negative relationship with maximum temperature, minimum temperature, evening RH and rainfall while it had positive relationship with morning RH. The meteorological data and the percent incidence of foot rot disease were subjected to multiple regression analysis. Results revealed that all weather parameters collectively influenced the disease incidence to an extent of 53.39%. After deletion of maximum temperature, morning RH, evening RH and rainfall, the R^2 value was 0.2082, which indicated the effect of minimum temperature on the disease incidence to an extent of 20.82 while the other four parameters together could influence the disease incidence to an extent of 32.57 only. The step down analysis revealed that for 1^{o}C decrease in minimum temperature, there was an increase of 1.44% disease.

At JNKVV, the incidence of disease recorded in the second week of June was 1.5%. The disease index increased gradually and reached to 22.15% in second week of September when the difference between maximum and minimum temperature is less and humidity ranged between 87 to 93 %. In the month of October, the incidence of stem rot increased within a range of 18.33% to 22.15 %. In correlation studies it clearly indicated that the disease development is positively correlated with RH, Rainfall, Number of rainy days with Number of cloudy days.

At BCKV, the correlation studies of different weather parameters with the disease incidence on variety simurali deshi revealed that x-coefficients for min. temperature (1.79), max. RH (1.38) and rainfall (0.02) had positive significant effect on percent disease incidence while that of max. temp. (1.09) and min. RH (0.18) had negative significant effect.

The correlation studies of different weather parameters with the disease incidence on halisahar jhal variety revealed that x-coefficients for maximum temperature (0.52) and maximum and minimum RH (0.75 and 0.26) had positive significant effect on percent disease incidence while that of min temp. (0.15) and rainfall (0.003) had negative significant effect.

At OUAT centre, influence of weather parameters like maximum and minimum temperature, afternoon RH and rainy days exhibited a positive significant correlation, whereas morning RH, rainfall, bright sun shine hours with the rate of evaporation indicated negative significant correlation towards the percent leaf rot disease incidence in betelvine caused by *Phytophthora* sp. The disease appeared in Baraja during 20th standard week and continued up to 47th standard week of the year. In the regression analysis of PDI with weather parameters, it was found that except morning RH, afternoon RH and rainfall, the rest of the parameters influenced significantly on PDI contributing to disease development. However, there is also a significant contribution of number of rainy days on disease development. In the regression analysis of percent disease development (PDI) with the weather parameters, it was observed that the rate of evaporation contributes to the extent of 75.73 % followed by the number of rainy days (12.66%) and minimum temperature (8.82%).

The influence of weather parameters like min temp, morning RH and rainy days exhibited significantly positive correlation contributing towards percent disease incidence of vine rot within 22nd to 49th standard weeks of the year (52weeks), whereas the other weather parameters like BSH, rate of evaporation, rainfall and morning RH exhibited negative correlation with vine rot disease incidence in betelvine.In the regression analysis of PDI with the weather parameters it was observed that only minimum temperature (8.0%), number of rainy days (8.0%) and rate of evaporation (82.25%) influenced PDI contributing to the extent of 98.00 % followed by bright sunshine hours (1.31%).

At RAU, minimum temperature, maximum and minimum RH coupled with precipitation (rainfall) per week under observation had positive effect, whereas maximum temperature, number of rainy days and number of cloudy days per week had negative effect on disease development of phytophthora leaf rot during the period. The important contributing environmental components for disease incidence were maximum RH above 90 per cent and minimum temperature 25.2 to 28.1^{0}C, which prevailed during the period, accounted for 18.3 and 10.3%, respectively to the total variation on disease incidence.

The correlation study between weather factors and per cent disease index (PDI) also indicated that minimum temperature, maximum and minimum RH and rainfall had positive effect, whereas maximum temperature, number of rainy days and number of cloudy days per week during observation had negative effect on per cent disease index (PDI) of phytophthora leaf rot. The important contributing environmental components were maximum RH above 90 % and minimum temperature 25.2 to 28.1^{0}C, which prevailed during the period accounted for 16.4 and 9.1 %, respectively of the total variation in per cent disease index.

At TNAU, the disease incidence had positive correlation with the weather factors viz., minimum temperature and relative humidity while the other factors like maximum temperature, rainfall and number of rainy days had negative correlation with the disease incidence.

Leaf rot caused by *Phytophthora* sp.

The results from the correlation studies of different weather parameters with the disease incidence on Simurali Deshi variety revealed that x-coefficients for min. temperature (2.45), max. RH (2.05) and rainfall (0.031) had positive significant effect on percent disease incidence while that of max. temp. (1.67) and min RH (0.36) had negative significant effect.

The correlation studies of different weather parameters with the disease incidence on Halisahar Jhal variety revealed that x-coefficients for min. temperature (0.96), max. RH (1.42) and rainfall (0.011) had positive significant effect on percent disease incidence while that of max. temp. (1.04) and min. RH (0.17) had negative significant effect.

Anthracnose of betelvine

At AAU, anthracnose disease appeared in the 3rd week of May and lasted up to 3rd week of September. The maximum and minimum temperature had significant positive correlation and morning RH and rainfall had negative correlation on the incidence and spread of the disease. However, the number of rainy days had positive co-relation.

At AAU, the anthracnose disease appeared in the 3rd week of May and lasted up to 3rd week of September. The maximum and minimum temperature had significant positive correlation and morning RH and Rainfall had negative co-relation on the incidence and spread of the disease. However, the number of rainy days had positive correlation.

At OUAT, weather parameters were significantly related to the incidence of anthracnose disease at varied levels throughout the year except rainfall, morning RH and rate of evaporation. Out of the weather parameters, minimum and maximum temperature, afternoon RH, number of rainy days and BSH were observed to be positively correlated with that of the incidence of anthracnose disease in betelvine plantations under closed conservatories. In the regression analysis of PDI with that of the weather parameters it was observed that maximum temperature contributed (4.20%), minimum temperature contributed to (9.9%) whereas the significant contribution for the disease incidence was recorded out of rate of evaporation contributing to 81.43 percent.

At RAU, maximum and minimum temperature, maximum and minimum RH and amount of precipitation during observations had positive effect whereas number of rainy days and number of cloudy days per week had negative effect on disease development in terms of per cent disease incidence of anthracnose of betelvine. The important contributing environmental factors for disease incidence were maximum RH above 90 %, maximum and minimum temperature ranging between 34.5-25.2^{0}C during the period of observation which accounted for 18.8, 17.4 and 11.9 % of the total variation in disease incidence, respectively.

The correlation study between weather factors and per cent disease index (PDI) also indicated that maximum and minimum temperature, maximum and minimum RH and amount of precipitation per week had positive effect whereas number of rainy days and number of cloudy days per week during observation had negative effect on per cent disease index of anthracnose. The important contributing environmental components were maximum RH above 90 %, maximum and minimum temperature ranging between 34.5-25.2^{0}C during the period of observation accounted for 16.3, 13.5 and 10.3 per cent, respectively to the total variation in the per cent disease index.

Bacterial leaf spot

At AAU, the bacterial leaf spot was observed two weeks after the appearance of the anthracnose i.e. in the first week of June and it lasted for a period up to 1st week of October with a peak period during the month of August. The co-relation studies revealed that maximum and minimum temperature had significant positive co-relation and morning RH and rainfall had negative co-relation with the disease incidence and development.

At JNKVV, the disease index of bacterial leaf spot increased gradually and it reached peak when rainfall was more, but from the month of September the incidence of bacterial stem infection increased and it was recorded maximum in the month of October. In correlation studies maximum humidity observed to be positively related with the disease development in bacterial infection of betelvine, whereas other factors like maximum temperature and rain fall had partially significant effect in the development of bacterial infection.

Integrated disease management of *Phytophthora* foot rot

At AAU, all the treatments significantly controlled the vine death and leaf diseases. However, the treatment of Sanitation + 1 application of BM at rainy season + after 1 month biological agent (*T. harzianum*) + 1 BM after 2 months of 1st BM was the best in controlling the disease and this treatment had produced highest leaf yield and showed best cost benefit ratio. Leaf diseases were significantly controlled in all the treatments where sanitation operation was done.

At BCKV, results showed that best prevention of mortality of vines was achieved in treatment comprising sanitation +one application of Bordeaux mixture at pre-monsoon + after one month, bio-control agent + one application of Bordeaux mixture 2 months after first Bordeaux mixture. Highest yield was obtained in this treatment with lowest leaf rot and leaf spot infestation. However, the cost benefit ratio was lowest in this treatment. Sanitation of betelvine garden proved cost effective.

At JNKVV, the minimum disease incidence of vine death due to *Phytophthora* foot rot and leaf rot (7.0%) and the incidence of vine death due to bacterial infection (7.5%) were recorded where four drenching of B.M .was applied, followed by proper sanitation + pre monsoon application of Bordeaux mixture + application of biological agent after one month application of Bordeaux mixture and second application of Bordeaux mixture two months after first application of Bordeaux mixture (7.16 & 9.83 %). In case of four drenches of Bordeaux mixture the disease incidence and per cent vine death were also reduced but when it is compared with percentage of profit over control than it will be less profitable than integrated disease management. Maximum yield was recorded with four drenches of Bordeaux mixture i.e. 37.66 lakh leaves ha^{-1} whereas in control 32.50 lakh leaves ha^{-1} was recorded.

At MPKV, the treatment comprising of sanitation + 1 application of 1% B.M. + Bio-agent one month after B.M. and treatment 5 i.e. sanitation + 1 application of 1% B.M. at premonsoon + after one month Bio-agent + 1 application of 1% B.M. two months after first B.M. application were at par in respect of yield against foot rot and leaf diseases with highest cost benefit ratio (Fig. 21).

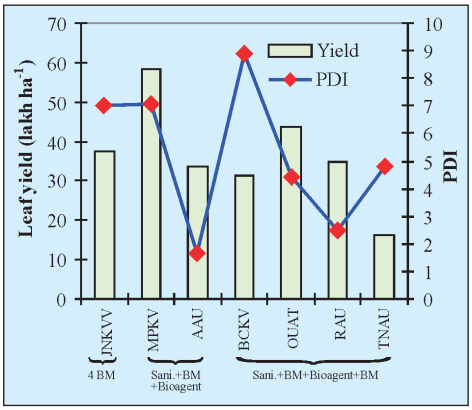


Fig. 21. Best treatment combinations of integrated disease management of phytophthora foot rot at various centres

At OUAT, the highest leaf yield (43.55 lakh ha^{-1} yr^{-1}) in the treatment comprising Sanitation +1 drench with B.M +bio control+ another drench with B.M followed by the treatment comprising Sanitation +1 drench with B.M+ biological agent one month after drenching (39.0 lakh ha^{-1} yr^{-1}) where the level of yield was found to be significantly different both at 5 and 1% level as well as with that of the control (21.65 lakh ha^{-1} yr^{-1}). However, a little difference in yield indicating statistically at par relationship at 1 percent level could be recorded among the treatments 2 (38.19) and 4 (39.00) and treatment 1 (35.75 lakhs ha^{-1} yr^{-1}) with treatment 3 (36.25 lakh ha^{-1} yr^{-1}).

It was found that providing sanitation alone inside the Baraja, the betelvine grower could obtain the highest return of 1:3.15, whereas by providing the sanitation to baraja and drenching once with B.M (1.0%) with the application of bio-control agent could enable the betelvine growers to get the monetary benefit of 1:2.95. The components like sanitation, two applications of soil drenching with B.M (1.0%) and single application with bio control agent *T. viride* could not only enable the farmer to get a good return (1:3.25) but also helped in getting a viable, sustainable and disease free baraj for a longer period.

At RAU, all the treatments significantly suppressed per cent disease incidence of leaf rot over control. All the treatments significantly increased yield in terms of number of consumable leaves per hectare over control. However, sanitation accompanied by drenching of Bordeaux mixture (1%) followed by soil application of bio-agent (*Trichoderma viride*) inoculated in mustard oil cake and one more drenching of Bordeaux mixture (1%) i.e. T_5 was found significantly superior to other treatments in respect of reducing per cent disease incidence of leaf rot, foot rot and thereby increasing the yield of marketable leaves $ha^{-1.}$

Significantly superior yield i.e. number of marketable leaves was obtained with T_5 which registered 34.80 lakh ha^{-1} followed by 3 drenches of Bordeaux mixture (1%), which yielded 32.84 lakh ha^{-1}. Sanitation alone could produce 24.6lakh ha^{-1} consumable leaves. Sanitation alone had no significant effect on reducing foot rot incidence indicating soil borne nature of the pathogen. Considering the cost return ratio, sanitation alone was found most economical producing Rs. 7.58 on investment of rupee one. But this treatment had certain limitations on suppression of leaf rot and foot rot incidence, which recorded 16.9 and 16.0 per cent against 26.8 and 17.5 per cent, respectively with control. Sanitation could produce 24.6 lakh ha^{-1} consumable leaves whereas control yielded 19.9 lakh ha^{-1}. Considering the productivity of the treatment T_5 i.e. sanitation along with soil drench of Bordeaux mixture (1%) on onset of rain followed by soil application of bioagent (*T. viride*) after 30 days of 1st drenching and thereafter next drenching of Bordeaux mixture (1%) produced Rs. 2.05 on investment of rupee one. Cost return ratio of the treatment T_3 i.e. sanitation + 1 drench of Bordeaux mixture (1%) was higher than T_5 but yield produced by T_3 was significantly inferior to T_5.

Significantly lowest vine mortality (4.80 %) was recorded at TNAU, in the treatment comprising of sanitation + one application of Bordeaux mixture (1%) at pre monsoon + one month after *T.viride* application + one application of Bordeaux mixture (1%) 2 months after the first Bordeaux mixture (1%) as against 13.96 per cent in control. The disease index in leaves was also minimum in this treatment (4.68) as compared to control (11.47). The cost benefit ratio was high (1: 2.30) as compared to other treatments.

Anthracnose leaf spot due to *Colletotrichum sp.*

The intensity of anthracnose leaf spot disease was recorded to be comparatively higher (32.35%) than the vine (26.50%) and leaf rot (29.75%) disease caused by *Phytophthora sp*. in the experimental plot. However, on integration of the treatment components there was a significant reduction in the incidence of anthracnose disease (11.25%) followed by the treatment with one drenching of B.M under sanitary profile (14.20 %) showing highly significant difference among the treatments.

Minor leaf spot diseases due to various fungi

At OUAT centre, the intensity of phyloplane diseases was observed to be maximum (38.65%) due to air borne mycoflora comprising of *Corynespora cassiicola, Cladosporium pipericola, Fusarium oxysporum* and *Aspergillus flavus* etc. causing various types of leaf spots in betelvine on var. Godi Bangla. The disease incidence was observed to be maximum 38.65 % in the control and minimum 16.10 % in the treatment, where sanitation was combined with B.M. drenching coupled with the bio-control agents.

Standardization of inoculum for mass multiplication of Trichoderma

At AAU and TNAU highest mean spores and mean colony-forming units were recorded when 60g of inoculums of *Trichoderma harzianum* were inoculated in 10kg of de-oiled cake and incubated for 60 days.

Fifty and sixty grams of inoculums were found to be best in producing highest spore concentration and colony forming units when 10 Kg of inoculated mustard oil cake was incubated for 60 days at JNKVV and RAU centres.

At BCKV it was found that wheat was useful as substrate for the production of mass culture of *T. harzianum*. The inoculum would be ready for distribution to the farmers after 10 weeks of inoculation as the chlamydospore production increased gradually even after 8 weeks of inoculation. Maximum chlamydospore production was recorded in 90 g inoculum concentration although it was statistically at par with 70 and 80 g inoculum concentration irrespective of number of weeks after inoculation and bajra/wheat seeds.

Shelf life of *Trichoderma viride*

Trichoderma viride was grown on maize meal medium and after 15 days of inoculation. Fungal culture was inoculated on potato dextrose agar medium at 15 days interval i.e. 0, 15, 30, 45, 60, 75 and 90 days after packing. Inoculated plants were inoculated in BOD incubator at 28 ± 1^0C and mycelial growth and sporulation were examined under microscope. It was noticed that mycelial growth and sporulation of *Trichoderma viride* were found viable up to 60 days of packing and on the 75th day of inoculation, mycelial growth and sporulation were not recorded indicating that the bio-agent remained viable up to 60 days in polythene pack at temperature range of 21-35^{0}C and beyond that period it lost its viability.

Demonstration of disease management technology developed by the centre in the farmers' field

Demonstration trials on disease management were conducted in different types of cultivation practices prevailing in Assam in the farmers' field at Chungajan, Natun Balai, Khowang, Ambagan, and Zingia. Five different fields were considered in each location to treat them as replication. In all the locations the yield and net income were higher when AAU technologies were adopted.

At BCKV centre, the demonstration showed that all the parameters except plant population and yield recorded significantly better in AINP technologies over the farmer management practices.

The field demonstration by JNKVV centre revealed that the percent vine death, percent diseases incidence in foot & leaf rot, bacterial leaf spot and stem infection as well as basal rot incidence were minimum in the treated plots as compared to the untreated plots. Yield and fresh weight of 100 leaves were also maximum in treated plots in comparison to untreated plots. The treated plots were significantly superior than untreated plots in all the five locations. Therefore, it was observed that the disease management package developed by JNKVV, under AICRP was highly beneficial to the betelvine farmers

The field demonstration results of MPKV revealed that the improved management package developed by the centre had significant impact on the control of diseases like foot rot anthracnose & bacterial blight as compared to untreated control on the farmers' fields at different locations. The percentage vine death was significantly low under treated plot (1.09% to 3.60%) as compared to untreated control (3.27 to 10.40 %). The improved management package had also reflected in the significant increase in the fresh wt. of leaves and leaf yield at different locations. On and average, there was increase in the fresh weight of 100 leaves by 17g and yield by 11.30 lakh leaves ha^{-1}. Economic analysis revealed that the cost benefit ratio was higher in treated plot over untreated at all the locations.

At OUAT center, the experiment was conducted in three villages. Improved technology like application of pre-monsoon Bordeaux mixture 1% as soil drench with 3 lateral drenching at monthly interval along with 0.5% B.M. application at 20 to 25 days interval with recommended doses of fertilizers (150 kg N, 100 kg P_2O_5 and 125 kg K ha^{-1} where the requirement of N was met from both organic and inorganic sources at 1:1 ratio) were applied. It was found that due to adoption of improved technology in variety and technology in resulted in the net monetary benefit was more for the farmers with minimum disease incidence. Similarly, the results of field demonstrations of disease management at 5 different places by TNAU centre showed superiority of AINPBV technologies over the farmer's practices.

Crop loss assessment due to insect pests and mites

Tobacco caterpillar

To assess the cumulative loss in leaf yield by the tobacco caterpillar, a trial was undertaken by ANGRAU centre. The results revealed that the plots treated with neem oil 0.5% spray significantly recorded a minimum mean leaf damage of 4.8% as against 21.2% in untreated plots. The cumulative number of leaves harvested ha^{-1} during the period of pest infestation was 4.47 and 2.96 lakhs per ha in protected and unprotected plots respectively. The percent loss in leaf yield was observed to be 32.4% with a cost benefit ratio of 1:4 by controlling the pest.

Mites

Similar trial by ANGRAU centre as indicated above was conducted against mites by spraying wettable sulphur 0.3% two times at fortnight interval during December. The plots protected against mite damage recorded a mean mite incidence of 4.7% where the check plots recorded 22.7%. A total loss of 37.8% in leaf yield was recorded due to pest. By keeping the mites under check, a net monetary gains of Rs.11, 800/- ha^{-1} with a cost benefit ratio of 1: 9.8 was obtained.

At MPKV, the average number of mites observed in dicofol treated plots remained significantly lower (3.1) over control (7.2) after every spray. The leaves coming from treated plots fetched 38.69 % more prices in the market over those from control plots. This reflected in to net returns of Rs.34866 h^{-1} with additional expenses of Rs.5468 on plant protection. The treatment with 0.05% dicofol for the control of mites in betelvine is utmost essential through which a net profit of Rs.34866 ha^{-1} could be obtained.

At TNAU, the leaf yield loss caused by red spider mite *Tetranchus cinnabarinus* was studied. The results revealed that the plots protected with wettable sulphur 0.15 percent spray significantly recorded lower number of mites $2m^{-1}$ vine ranging from 0.0 to 0.13 with a mean of 0.07 as against 0.25 to 2.44 with a mean of 0.75 in unprotected plots from August, 2004 to March, 2005. Monetary loss due to red spider mite damage in treated area ha^{-1} was Rs.10, 450/- and the monetary loss due to mite damage in untreated area ha^{-1} was Rs.42, 800/- (10,000 leaves cost Rs.500/- on an average). 36.95% loss of marketable leaves due to red spider mite was recorded in untreated plots and 14.54% loss of marketable leaves due to red spider mite in treated plot was recorded and the cost benefit ratio was 1:13.94.

Scale insect

AT TNAU centre, the results revealed that the plots protected with Chlorpyriphos 0.05% spray significantly recorded lower number of linear scale insects $vine^{-1}$. Monetary loss due to pest damage in treated area ha^{-1} was Rs.14, 500/- and the monetary loss due to pest damage in untreated area ha^{-1} was Rs.41, 150/- (10,000 leaves cost Rs.500/- on an average). A total loss of nearly 36% marketable leaves due to linear scale insect, 14% loss of marketable leaves due to scale insect in treated plot and 58% loss of marketable leaves due to linear scale insect in untreated plot were recorded. The cost benefit ratio was 1:14.99.

Black fly and white fly

A study was taken up for assessment of crop loss due to the attack of aleyrodid fly complex (white fly and black fly) on betelvine variety Simurali Deshi (Bangla) at BCKV. Paired plot technique with 16 replications was followed for the study. In each replication both treated and untreated plots were maintained. Imidachloprid (0.003%) was sprayed at an interval of one and half month during the period of experimentation to keep the treated plot free from fly infestation. The fly population was recorded in the untreated plots at fortnightly interval from August- December. Unprotected plots recorded an incidence of white fly and black fly ranging from 7.9 to 62.7 per vine with a mean of 43.4 per vine. The protected plots harboured negligible (almost nil) number of flies. The yield data showed that there was a reduction of 13.39 % leaf yield in unprotected plot. At the same time the quality of leaves in unprotected plots was also lower (smaller sized, bad texture and loss of lustier) which fetched lower price than the leaves from protected plot. Over all monetary loss due to pest damage was Rs 17,029/- ha^{-1} (29.63%) for five months.

Screening of betelvine cultivars against whitefly

At BCKV, the results showed that there were great differences among the

entries for whitefly infestation level. None of the entries under observation was completely free from whitefly infestation. Entries may be grouped in three categories according to the level of infestation: varieties with <15 WF /vine, 15-30 WF/vine and > 30 WF/ vine. Kalipatti and Simurali Sanchi are in the first group showing moderate resistance. Bagerhat Bangla, Awani, Harishpur Bangla, Jabalpur Bangla and Kadwa are in the second group being moderately susceptible. Rest 13 cultivated varieties being highly susceptible having population of whitefly more than 30 per vine.

Screening of betelvine cultivars against betelvine bug

At MPKV, the observations revealed that the Betelvine bug preferred to feed upon tender leaves (top or middle). All the cultivars from Bangla group *viz*. Bangla Bihar, Bangla Banarasi, Calcutta Bangla, Nava Cuttak, Dese Bangla, Bangla Mohoba, Maghai, Bangla Ghamela, and Bangla Ghaneghatte remained uninfested.

Population fluctuation of different mite species in betelvine garden

A few mite spp. of nine groups (family) were recognized from recent observations on betelvine at BCKV. Among the species observed, only destructive nature of *Brevipalpus phoenicis* was observed. The characteristic symptoms of this mite on betelvine were blackish lesions at the ventral surface especially near the margins of the leaf. Gradually the blacken spots spread all over the leaf that eventually enhanced maturity and drying of the leaf. The matured leaves were most infected than the younger leaves. A study on the population fluctuation of *Brevipalpus phoenicis* was taken up from November'05 at Kalyani in a fixed boroj on variety Simurali Deshi. Monthly data on population of mite showed that from November the population gradually decreased and low during December and January, and then it again increased in the following months. Maximum 1.5 and 0.5 mites per matured and young leaf were observed respectively.

Management of mites in betelvine garden

AT MPKV, the percent reduction in mite population caused by wettable sulphur 0.15 % + azadiractin 0.03% was found significantly superior over all other treatments as seen at 3,7 and 14 days after each spray. It was followed by wettable sulphur 0.05% used either alone or in combination with N.S.K.E.5%. The highest C: B ratio of 1:43.5 was found in treatment with wettable sulphur 0.15% + azadiractin 0.03%. It was followed by wettable sulphur 0.15% (1:40.96). The conventional miticide, wettable sulphur 0.15% was found to be highly effective for the management of mites in Betelvine.

At ANGRAU, the plots were treated with wettable sulphur 0.3% recorded minimum damaged leaves (5.6%) whereas, the untreated plots recorded 20.2% damaged leaves and found to be as effective as dicofol in reducing the mite incidence. Higher leaf yield of 6718.7 bundles ha^{-1} was recorded when wettable sulphur 0.3% was sprayed with an extent of 43.3% over check during the period of pest infestation.

Management of red spider mite

The trial was conducted with SGM1 variety at TNAU centre. The population of red spider mite was counted at peak incidence on three leaves *viz*., lower; middle and

upper leaves in 10 randomly selected vines for each replication and the treatments were imposed. Post counts red spider mite population were male on day 3, 7 and 14 days after the treatment. The population counts indices were converted to percent reduction over control. The mean pre treatment red spider mite population ranged from 7.80 to 8.60 and did not differ significantly in the first year of field study. The application of *Beauveria bassiana* @ 5g lit^{-1} wettable sulphur 0.15% either alone or with neem products such as NSKE 5%, neemoil 2% and azadirachtin 0.03% was found at par and significant over other pecticides in reducing the mites effectively in betelvine. However, the effect of *B. bassiana* was observed from 7 days after application. All pesticides were found significantly superior over control in reducing numbers of damaged leaves due to mites. The combination of wettable sulphur 0.15% + Azadirachtin 0.03% was found to be best treatment for effective management of mites thereby reducing number of damaged leaves (4.82 lakh ha^{-1}). However, this treatment remained at par with all other treatments except treatment NSKE (8.21 lakh ha^{-1}) and neem oil (11.32 lakh ha^{-1}). The control plots were badly damaged having 21.11 lakhs of damaged leaves per ha. The C: B ratio was highest (1:99.7) for treatment with wettable sulphur followed by wettable sulphur + Azadirachtin (1:77.1). The treatments with NSKE 5% gave the lowest C: B radio of 1:10.00. The maximum net profit to the tune of Rs.38, 904 ha^{-1} was obtained from the treatment wettable sulphur 0.15%. The conventional miticide wettable sulphur 0.15% was found to be highly effective for the management of mites in betelvine. Average price fetched for infested and a healthy leaf is Rs.400 and 700/- dag (i.e. 12,000 leaves), respectively. Cost of hired spray pump and wages payable to labourers was considered as Rs.10 and 75 day^{-1}, respectively. The cost of neem seed, wettable sulphur, *B. bassiana* was considered Rs.5, 50 & 150 kg^{-1} while that of neemoil & Azadirachtin Rs.70 and 210, respectively.

Screening of betelvine cultivars against tobacco caterpillar and mites

Field screening

The available germplasms (51 No's) were tested against the incidence of tobacco caterpillar and mites under field conditions at ANGRAU. The pungent varieties recorded the less incidence of tobacco caterpillar with 1.4 to 13.7% damaged leaves as against 10.2 to 37.1% in non-pungent varieties. Among pungent varieties, the incidence was negligible (1.4 to 3.1%) in Bangla (U. P.), Kali bangla (W. B.), Awami Pan (W. B.), Black leaf (A. P.), Simarali Babna Local (W. B.), Nov Bangla (Orissa), SGM-1 (T. N.), Godi Bangla (Orissa) and Maghai (Bihar). Relatively lower incidence of 10.2 to 17.3% damaged leaves was recorded in non-pungent varieties of Vellai kodi (T. N.), Kapoori Arvi, Gangeri (A. P.), Yellow Leaf (A. P.), Swarna Kapoori, Tellaku Utukuru (A. P.) and Pachai kodi (T. N.).

The mite incidence ranging from 5.1 to 15.3% and 7.5 to 22.0 was recorded in pungent and non-pungent varieties respectively. Lower incidence with 5.1 to 5.4%-damaged leaves was recorded in the pungent cultivars of simarali Babna Local (W. B.), Bangla (M. P.), SGM-1 (T. N.), Calcuttia Bangla and Ramtek Bangla (Mah.). Similarly in non-pungent cultivars, Meetha Pan (W. B.), Swarna Kapoori and Kapoori Chitti kavata (A. P.) recorded lower mite infestation of 7.5 to 9.8%.

Laboratory studies

In order to identify the reasons for any host resistance to tobacco caterpillar,

laboratory studies were undertaken. First and second instar larvae did not survive when fed with pungent and non-pungent varieties. Higher survival of larvae ranging from 26.6 to 33.3, 66.0 to 80.0 and 86.6 to 93.3% in third, fourth instar larvae respectively was recorded when reared on non-pungent cultivars as against lower survival of larvae ranging from 0.0 to 13.3, 13.3 to 26.6 and 26.6 to 53.3% when reared on pungent varieties. Higher mortality of the larvae in the pungent varieties might be due to the presence of higher amounts of certain toxic compounds in pungent leaves.

The relative susceptibility of forty-five clones was tested against linear scale insect at TNAU centre. The screening for scale damage was carried out under natural conditions during peak period of damage when the scale population was present under insecticide free environment. There were 25 vines for each clone and a single vine constituted a replication arranged in CRBD. Three leaves from top, middle, bottom were randomly collected from each vine and vines were categorized. Out of 45 clones 10 clones did not exhibit damage while in the rest of the clones the intensity of population varied from 0.2 – 24.00 mean number of scales vine^{-1}.

Categorization

Scales 0/Vine: Kapoori, Tellakku, Vellaikodi, Karapakku, Kuljedu, Sirugamani Bv2, Anthiyur, Tellaku Uttukar, Sarkaraikodi, Halisagar sanchi.

Scales 0.5 /vine: Maghai, Kallipatti, shirpurkatta, vasanaikodi, Banchikodi, PK mutant, Black leaf, GN1, P2, P3, Bangla Kapoori, Nava bangla, Jabalpur bangla, Gachpan, Ghanaghattae, Bangla nagaram, Mysorekodi, Bhainchaguri, Desi bangla, Meetha, P1.

More than 5 scales/vine: SGM1, Bangla, Bangla Ramtek, Bangla Jal, Desawari, Mysore chigaru.

Germplasm screening for Red spider mite resistance

Field tolerances to 45 clones to red spider mite was assessed and were categorized based on damage grade index (DGI) 0-11 scale under field condition. 32 entries did not exhibit damage and the reaction of remaining 13 entries screening results revealed that Jabalpur bangla, Gach pan, Kallipatti exhibit field tolerance to red spider mite (0.2 mean damage grade index.

Management of insect pests of live standards

At ANGARU centre, among safer insecticides, minimum mean leaf damage of 9.9% and 10.3% was recorded in the plots sprayed with neem oil 0.5% and NSKE 5% respectively as against 24.7% damaged leaves in check plots. Other effective treatment was *B. bassiana* @ 5 g of product lt^{-1} of water (at a spore concentration of 1.8 x 10^6 ml-1) with mean dagamed leaves of 10.4% which was followed by *B.t.* @ 1.0 kg ha^{-1} and NPV @ 500 L.E ha^{-1}. An increased leaf yield 37.3% over check was recorded by controlling the pest with neem oil 0.5% during the period of pest infestation.

Fixing ETL for important pests

Tetranychus cinnabarinus

Experiment to assess the loss in yield of betelvine (SGM1) by red spider mite *Tetranychus cinnabarinus* was carried out at TNAU, under pot culture conditions. Stock culture of *Tetranychus cinnabarinus* was maintained in potted betelvine plants and in alternate host moringa prior to experiment. There were significant differences in damage grade indices with respect to various treatments. Maximum damage occurred to vines infested with 100 mites per vine as indicated by damage grade index (5.67) followed by vines released with 50 mites (4.78), 25 mites (4.11), 10 mites (3.22), 7 mites (2.55), 5 mites (1.56), 3 mites (0.89) and 1 mite (0.0). In control, where monocrotophos 0.05% was sprayed, no damage symptom was observed and the leaf yield was highest (52.67 leaves vine^{-1}). The leaf yield recorded from the vines released with 5 mites per vine was drastically lower and significant (37.00 leaves vine-1) leaf yield recorded from vines released with 7,10,25,50 and 100 mites were significantly lower than 3 mites plant^{-1}. It was found that *T. cinnabarinus* was an important pest of betelvine, which caused significant yield loss even at population of 5 mites per vine after lowering. The loss caused was substantial since bronzing symptom and poor growth affected marketability. It was evident from the study that betelvine could tolerate infestation of T. *cinnabarinus* when the attack was upto 3 mites vine^{-1} (upto 2m height) without affecting the yield.

Linear scale insect

SGM1 was used for the field study at TNAU centre. As soon as the linear scale appeared in the field, the crop was exposed to the linear scale for varying periods of exposure. There were nine treatments (complete protection) 1,2,3,4,5,6,7 weeks of the linear scale exposure and unprotected control. After the exposure of the crop at the respective period, the corresponding treatments were kept linear scale free by spraying Methyl 0 dematon (0.025%). The linear scale population on 2m vines was recorded on 30 randomly selected plants per replication at weekly intervals. Preliminary results revealed that the cost benefit ratio increased progressively from one to three weeks of exposure during the period of investigation. The decrease in the ratio in the crop having more than 3 weeks of exposure to the linear scale was due to delay in protection of the crop during the subsequent exposure period. Though the cost of protection decreased with increase in exposure period but there was reduction in yield due to longer exposure of the crop to the linear scale. It is therefore suggested that for effective linear scales management, control resources should be started at third week of scale appearance for 2m vine length and there after need based spray is advisable to keep the scale population below economic injury level.

Control of whitefly by some botanical insecticides

An insecticide trial was done to study the efficacy of some botanical insecticides against whitefly in the betelvine at BCKV. Insecticides were applied three times with a compressed air hand-held sprayer at 15-day intervals. Triton AD @ 1ml L^{-1} was mixed with all treatments. Water was sprayed with Triton AD in untreated control. The effects of treatments on the fly were determined by counting the number of nymphs at 15 days after third spray. Three leaves, one in each case from the upper, middle and lower sections from each of five vines

selected at random in each plot were taken to see the nymphs pupa^{-1} under stereo binocular microscope. The results revealed that Cal MB (0.15%) was the superior among the botanical insecticides tested and also showed higher efficacy than that of recommended synthetic Dichlorvos (.05%). Neem Oil (0.3%) was also effective though less than above two.

Management of insect on Sesbania (Live support on betelvine)

At TNAU, the stemborer incidence was negligible in the trial plot. The incidence of sesbania stem weevil *Alcidodus bubo* was noticed above threshold level. The symptoms showed single galls on the stem. The methods of assessment included destructive sampling to see the live insect stages or growth parameters of plants like height, stem girth and vigour to support the vines. The treatments included drenching and spraying of botanicals and bio control agents at monthly intervals. The observation on mean height, stem girth and number of live stages was noted on 30th day after treatment. Entomogenous fungus *Beauveria bassiana* 5g lit^{-1} (1.8 x 10^{6} spores gm^{-1}) was found to suppress the stem weevil followed by NSKE 5% spray 3 times at monthly interval.

GERMPLASM HOLDING OF MEDICINAL & AROMATIC PLANTS

Germplasm status of NRCMAP field gene bank

Sl. No.	Plant	Total
1	*Aloe* spp.	54
2	*Andrographis paniculata*	59
3	*Asparagus* spp.	46
4	*Cassia angustifolia*	5
5	*Chlorophytum borivilianum*	54
6	*Commiphora*	67
7	*Cymbopogon flexuosus*	13
8	*Datura* spp.	2
9	*Evolvulus alsinoides*	3
10	*Phyllanthus* spp.	13
11	*Tinospora cordifolia*	38
12	*Tribulus terrestris*	7
13	*Urgenia indica*	6
14	*Withania somnifera*	11
15	*Plantago* spp.	8
Total		**386**

PLANTING MATERIAL/RAW MATERIAL PRODUCED

Name of the centre	Material produced	Quantity of the material produced
NRCMAP, Anand	Seeds of senna, muskdana, kalmegh, ashwagandha, isabgol, asalio, mustard	4137.2 kg
	Roots of ashwagandha, asparagus (dry roots), guggal (rooted plants); dry veg. part of kalmegh.	756.2 kg and 123 nos.
	Slips & leaves of lemongrass, palmarosa, patchouli (plants), guggal (cuttings), aloe (suckers).	151544 nos. and 1062 kg (lemongrass leaves)
AAU, Anand	Seeds of isabgol, senna, asalio, ashwagandha, shankhpushpi, kalmegh, safed musli (root)	377.8 kg
	Seedlings/plants of aloe, guggal, asparagus, dodi, gymnema, damvel, kalmegh and other medicinal plant species.	31330 nos.
NDUAT, Faizabad	Seeds of opium poppy, kalmegh, ashwagandha, asparagus, isabgol, sarpagandha.	177 kg (seed) and 209 kg (seed mixture)
	Gum of opium poppy	5.990 kg
	Powder of kalmegh	15 kg
	Roots of ashwagandha	6.5 kg
	Seedlings and plants of asparagus & sarpagandha	4340 nos.
	Slips of lemongrass	200 slips
	Safed musli	50 kg
YSPUH&F, Solan	Rooted cuttings in polybags & naked, nursery seedlings and tubers of different medicinal plants.	8469 nos.
	Seeds and dry herbage	35.5 kg
MPUAT, Udaipur	Seeds of opium poppy, ashwagandha, isabgol, babchi, asalio.	432.8 kg
	Fasciculated roots of Safed musli	31 kg
	Dry roots of ashwagandha	82 kg

General Information

COMMITTEE MEETINGS

Institute Management Committee (IMC) Meeting

The 12th IMC meeting was held on 11th May, 2004. Besides the chairman Dr. Satyabrata Maiti, Director, NRCMAP, Mr. D. S. Surana, Nominee of ICAR President, Dr. R.S. Kurothe, Dr. P. P. Joshi, Dr. S. Samantaray, Mr. N. S. Rao, Shri V. S. Parmar and Mr. T. A. Vishwanath, AFAO attended the meeting. The committee reviewed the various research and developmental activities of the institute and suggested a number of measures to speed up the development of the institute. The 13th IMC meeting was held on February 3, 2005 under the chairmanship of Dr. Satyabrata Maiti, Director, NRCMAP. It was attended by Dr. K. V. Ramana, ADG (PC), ICAR; Dr. R. S. Kurothe, Head, CSWCR&TI, Vasad; Dr. P. P. Joshi, Principal Scientist; Dr. (Mrs.) Sanghamitra Samantaray, Sr. Scientist; Mr. N. S. Rao, Scientist; Mr. T. A. Vishwanath, AFAO and Shri V. S. Parmar, AAO as members. The committee reviewed the various research and developmental activities of the institute and suggested a number of measures to speed up the development of the institute.

Research Advisory Committee Meeting

The second Research Advisory Committee (RAC) meeting of NRCMAP was held on 19th January, 2004. Dr. P. Pushpangadan, Chairman, RAC expressed his pleasure on the overall growth and development of the institute. He highlighted that the demand for medicinal plants used against age related problems would increase and suggested to initiate work on such crops. Dr. Satyabrata Maiti, Director, NRCMAP presented the Action Taken Report and highlighted the achievements made by the Institute. The Chairman and the Members of the committee gave several useful suggestions for the future course of research.

Third Research Advisory Committee (RAC) Meeting of the institute was held on February 2, 2005 under the Chairmanship of Prof. K. V. Peter, Vice Chancellor, Kerala Agricultural University, Thrissur; Dr. G. N. Qazi, Director, Regional Research Laboratory, Jammu; Dr. O. P. Srivastava, Director, Institute of Agricultural Sciences, BHU, Varanasi; Dr. K. V. Ramana, ADG (PC), ICAR and Dr. Satyabrata Maiti, Director, NRCMAP were members of the committee. The Chairman and members were honoured by presentation of bouquets by Dr. S. Maiti and were welcomed by Dr. S. Samantary, Member Secretary, RAC. Prof. K. V. Peter expressed that phytochemistry must play an important role in medicinal and aromatic plants research. He suggested that coordination and networking with other medicinal plant boards, national institutes, private agencies, etc. were essential. He was happy to proclaim that the centre could be an institute within next 4 to 5 years and then could acclaim to be a deemed university. Dr. G. N. Qazi, expected this center to provide the most

appropriate and accurate raw material. He invited research collaboration between the NRCMAP and RRL. He also suggested that NRCMAP might also work at least on two to three crops covering studies on all aspects by which it would develop authority on these crops and also could become certifying agency in future. Dr. Srivastava opined that collection and screening of old literature related to medicinal and aromatic plants would be of much significance. He suggested taking up studies on production of secondary metabolites due to stress, study on micronutrients deficiency, toxicity and working on analysis of soil and crop in relation to requirement of particular nutrient. Dr. K. V. Ramana desired to add clinical aspects in the mandate of NRC in near future. He also emphasized on prioritization and focused work.

Staff Research Council Meeting

Staff Research Council (SRC) meeting of the institute was held on 26th June and 8th November, 2004 under the chairmanship of Dr. S. Maiti, Director, NRCMAP. Individual scientists presented progress report of the nine institute-funded projects. The projects covered the improvement, production and chemical evaluation aspects of seven medicinal and aromatic crops. Four new projects one each on biotechnological characterization, computer based programme development on medicinal and aromatic crops, organic crop production and irrigation scheduling based on IW:CPE were also discussed and approved.

Review discussion of AINP on MAP

Workers of the All India Networking Project on Medicinal & Aromatic Plants (AINPMAP) took part in a six days review discussion at NRCMAP, Anand during 24 – 30 June, 2004. A total of 35 Scientists from different Agricultural Universities working under the umbrella of AINPMAP took part in the discussions along with the Scientists from the NRC. In the beginning of the review discussion, Dr. Satyabrata Maiti, Director NRCMAP & Project Coordinator AINPMAP welcomed all delegates and explained that this discussion was to reorient the research activities and to prepare a road map for next five years in terms of technical programme. He told that the shift from Coordinated mode, in which this project was running, to Networking mode was significant.

In the new form, the scientists working at different locations would collaborate to complement each other. This would help in achieving the research targets easily within short period of time. He also advised the participating scientists to take this opportunity as soul-searching exercise. He highlighted the achievements made under the AICRPMAP however, opined that there were scopes for improvement of this programme. He informed that aspect like organic cultivation was catching up globally and especially in the medicinal plants; these areas were needed to be worked out more thoroughly. Since global consumers are becoming aware of the hygienic values, he cautioned that our research should be able to provide extremely low residue of the toxic chemicals in the commodities. He also suggested that it should be borne in mind that our research should be farmer oriented and the technologies developed should be accepted by the farmers.

The delegates discussed for two days each on aspects viz. crop improvement, crop production and crop protection and phyto-chemistry. Under each aspect

scientists presented the work done so far and also identified the research gaps. New research proposals were formulated after thorough discussions.

Group meeting of the AINP on Beletvine

Twentieth Group meeting of the All India Networking Project on Beletvine was held at Acharya N. G. Ranga Agricultural University, Bapatla during December 2-4, 2004. The inaugural function was presided over by Dr. A. Padma Raju, Director of Research & Dean of Agriculture. In his welcome address, Dr. A. Thirupati Reddy, Associate Director of Research, RARS, Lam Farm, Guntur gave a brief description of the prospects and opportunities of beletvine cultivation. Dr.Satyabrata Maiti, Project Co-ordinator, AINP on Beletvine presented salient achievements made by the various networking centers during the last two years. He highlighted that at eight centres located in Agricultural Universities, 24 scientists of various disciplines conducted research on various aspects. Major emphasis was given on water management, organic farming and development of IPM for major insect pests and diseases. Three multi-location experiments in crop improvement, six in crop production, five on plant diseases, three in nematode disorders and eight in insect pests and mites in addition to three station trials were conducted. He also mentioned that the demonstrations of disease management technologies conducted by ANGRAU, AAU, BCKV, OUAT and TNAU centres in the farmer's field proved better in terms of disease reduction, higher yield and higher cost benefit ratio.

Dr. A. Satyanarayana Reddy, Member of Board of Management, ANGRAU gave a felicitation address to the gathering. He suggested some vital points for refinement of the technical programmes and cautioned to consider the cost : benefit before recommending any new package of practices.

Sri. Gade Venkata Reddy, MLA, Bapatla addressed the gathering on this occasion. He informed the house that Andhra Pradesh is contributing a considerable share in Indian agri business. He praised the scientists for their efforts in betelvine cultivation.

Dr. S.N. Pandey, ADG (PC) and Chief Guest of the function appraised the house about existing broad framework of functioning of the project since its inception. He emphasized on excellent research in Beletvine and assured Council's full support for the project. He informed that in the present WTO scenario characterization of germplasm would be very important.

The discussion was held in three technical sessions one each for crop-improvement, -production and –protection. Recommendations like use of drip irrigation, bio-fertilisers, bio-control agents, etc. were emerged from the discussions. The technical programmes formulated were presented in the plenary session. The meeting ended with the vote of thanks proposed by Dr. S. Maiti.

OTHER ACTIVITIES

Training programmes on digital photo library

Training programmes on Digital Photo Library of Medicinal and Aromatic Plants were conducted at NRCMAP on 28-29 January and 23-24 April, 2004. Ten participants from six Institutes took part in the programme. Dr. Satyabrata Maiti, Director, NRCMAP explained the genesis of the programme. The Institute initiated a project to create a digital photo library of medicinal plant species in a systematic manner so as to remove confusion and ambiguity in plant identification by common man. Dr.G. Kalloo, DDG (Horticulture & Crop Sciences), ICAR was impressed to see this endeavour and suggested that training programmes might be organized so that such Photo Libraries be developed at all ICAR institutes. The chief guest of the inaugural function, Dr. D. J. Patel, Principal, B. A. College of Agriculture, Anand listed the benefits of the digital photographs. He also explained the importance of the use of photographs in scientific presentations. He urged the participants to use the knowledge of this training programme at their own field of research. The training was subdivided into theory and practical. Basics of photography, digital photography, field level photography and software used to develop the library were explained to the trainees.

Visit to Malaysia

Dr. Satyabrata Maiti, Director, NRCMAP visited Malaysia during August 15-22, 2004 to attend IPGRI/RDA Regional Training Course on Development of Descriptors for Medicinal Plants and Information Documentation Asia Pacific Medicinal Plants Research Meeting. The purpose of the visit was to deliver a paper in the e-descriptor training programme as resource person, to train participants from 12 Asian countries on the techniques of descriptor development for priority medicinal plants, to train the participants on data entry in the medicinal plant database, to develop action plan on the phase II country project proposal and to chair a session in the e-descriptor training programme.

The countries viz. Bangladesh, China, India, Indonesia, Korea, Lao PDR, Malaysia, Mongolia, Nepal, the Philippines, Sri Lanka and Vietnam participated in the meeting.

The genesis of the programme was drawn with scope of work to document published and unpublished literature on medicinal plants, to document conserved medicinal plants in 12 Asia Pacific countries and generate information on these accessions, to summarize the status of research on each medicinal plant in each country, present research results and identify research gaps and to identify priority medicinal plants per country and priority research areas.

It was concluded that IPGRI would develop an update of manual to address experiences of participants of training course and other expected constraints and include in the manual a step-wise illustration of at least one medicinal plant species.

This training course was designed to develop standardized descriptors to make the proper identification of medicinal plant species and genotypes more accurate and less time-consuming but also orient people involved in the project

in using e-descriptors. Electronic descriptors, or e-descriptors for short, provide an opportunity to choose specific descriptors for different plant species from an already standardized set of descriptors and descriptor states. Moreover, web-based documentation of information on medicinal plants would enable project participants to continuously update needed data from their respective countries during the project period and beyond, thereby contributing to building-up a comprehensive medicinal plants database for use in further research and for information-sharing between and among partners and stakeholders.

A draft recommendation has been prepared for development of projects in areas of common interest in future. It was recommended that one reference library for all the partner countries should be established in one of the partner institutes with an objective to collect and disseminate publications related to medicinal plants in partner countries. India being the pioneer country to have exclusive institute for Medicinal plants may take the lead in this area. Also herbal homepage be developed for the project to disseminate research results, current and future event and activities on medicinal plants. A task force was proposed with the countries like Korea, India and Philippines.

It has been proposed to establish an interim Information Dissemination Unit including a project homepage through India.

Hindi week celebrated

The Centre celebrated Hindi week during 13-18 September, 2004. During this week, several competitions viz. Hindi vocabulary, Hindi debate, Hindi recitation, Hindi essay writing.etc. were organized. Offical Language Implementation Committee of the Centre organized a small function to commemorate Hindi day at the end of the week. The chief guest of the function, Dr. Madam Mohan Sharma, Senior Reader, S.P.University, Anand felt that any step towards enforcing the Hindi language in school curricula would create negative impact in the people. He urged the need to bring awareness about the use of this language among the common man. Shri. Suresh Chandra, Hindi officer, Central Bank of India (Regional Office), was the guest of honour in the function. He suggested the need to spread the technologies using Hindi that would help people to understand with ease. In his presidential address Dr. S. Maiti, Director, NRCMAP expressed that it would not be sufficient to remember Hindi language once in a while by organizing such functions. He stressed that use of Hindi in day-to-day work would be necessary. The function ended with vote of thanks to the Chair.

Annual day celebrated

Foundation of the Centre was observed as the Annual day on 24th November, 2004. A humble function was organized by the Staff Welfare Club to commemorate the occasion. The members of the NRC family along with their family members observed the day with fan fare. The function started with welcome address by Dr.P.P.Joshi, Principal Scientist. He also presented a brief note on achievements of the Centre. He congratulated all the members on this occasion and wished a very happy march forward so that everybody can uphold one's esteem and dignity by doing best for the NRC. The function was then flagged off by lighting of traditional lamp. Cultural programmes and few friendly games were also organized on the day.

Vigilance awareness week observed

One day workshop was organized at NRCMAP, Boriavi to create awareness about vigilance among all staffs which was presided by Dr. S. Maiti, Director, NRCMAP. The workshop started with the pledge administered to the officials and staffs. Some selected lectures were delivered by officers and scientists wherein various aspects of vigilance were covered. Main cause of corruption was dealt with by Dr. Maiti in his presidential address. He highlighted the means of corruption and various options to fight out corruption from daily life in general. He emphasized that corruption can never be eradicated completely but can be smoothly minimized following honesty, positive thinking and with strong moral character. However, the institute observed the vigilance week during November 1 to November 6, 2004 by keeping records open for verification to bring transparency which would root out the corruption to a great extent.

Women cell

Women cell of the center had regular meetings wherein welfare of all the women staffs was thoroughly discussed. It was a matter of great pleasure that all the women staffs of the center enjoyed the environment in the premise and expected a sustainable positive culture to prevail. They took pledge to uphold the name and fame of the center and would take part in all the activities besides their normal work. Women staffs also participated in both Annual day and Hindi week of the center and won several prizes.

Video film on medicinal crops developed

Television plays an important role in mass education. ICAR took steps to disseminate the technologies developed at different research institutions amongst the end users through TV. Towards this goal, NRCMAP developed a video film on "Cultivation of Rabi Medicinal Plants". This film of 15 minutes duration depicts the cultivation practices of three important medicinal crops of post kharif and winter season – ashwagandha, isabgol and opium poppy.

Meeting of DBT Project

Meeting of Co-ordinating centres of the DBT sponsored Project on "Biotechnological approaches for production and cultivation of Patchouli" was held on 3rd May, 2004 at NRCMAP. The meeting was chaired by Dr. S. Maiti, Director, NRCMAP. In his introductory remark, he briefed about the activities of the Centre in research and technology development. He also highlighted the importance of aromatic plants and the growing global market as well as alternate usages of aromatic oil in aromatherapy, as food products, as flavour, fragrance, etc. It was followed by the presentation by the PIs from different centers. It was revealed that crop growth was good at UAS, Dharwad, Karnataka and B.S.K.K.V, Dapoli, Maharastra. However, the centres like NRCMAP and CPCRI, Kasargode sustained with poor establishment of the plants. The chairman expressed that in future, finalization of the experiments and treatments for each centres must be done in a group meeting having thorough discussion on requirement of the experiments and treatments to fulfil the objectives.

Promotion

- Mr. C. K. Vankar's pay scale upgraded under the ACP scheme

Our New Colleague

- Ms. Deepa Bhagat, Scientist (Organic Chemistry) joined NRCMAP on 27.4.2005

PUBLICATION
Research Paper (Medicinal & Aromatic Plants)

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Seminars /Symposia/Conference/Lecture delivered/attended

NRCMAP

Das, M (2004) Attended State Credit Seminar, Organised by NABARD at Ahmedabad on 23.12.2004.

Maiti S. (2004) Lecture on Prospects of medicinal plants cultivation in Gujarat at CS&WCR&TI, Vasad on 5.4.2004.

Maiti S. (2004) Lecture on Prospects of medicinal plants cultivation in Gujarat at CS&WCR&TI, Vasad on 17.5.2004.

Maiti, S and K. Mandal (2004) Status and need for mechanization of production operations in medicinal and aromatic plants. In *National Working Group Meeting on Mechanization of Horticulture and Hill Agriculture* at CIAE, Bhopal during 16-17, April, 2004, 100-105.

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Mandal, K (2004) Attended State Credit Seminar, Organised by NABARD at Ahmedabad on 23.12.2004.

Raju, S (2004) Attended State Credit Seminar, Organised by NABARD at Ahmedabad on 23.12.2004.

Rao, N. Srinivasa (2004) Attended workshop on "Interface discussion on market potential for medicinal plants of Gujarat" held at Anand Agricultural University, Anand on 22.09.2004.

Rao, N. Srinivasa (2004) Attended advisory committee meeting for the development of ICAR websites held at NBPGR, New Delhi on 8.10.2004.

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NDUAT, Faizabad

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Ram, D., J. Prasad and Sri Narayan (2005) Present status and future prospects of Safed Musali in Uttar Pradesh. In National Semi*nar on Recent Advancement Medicinal & Aromatic Plant"* held at 15-17 February in S.V.B.P.A.& T, Meerut (U.P.).

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Deen, M.K., O.P. Yadav and C.S. Tyagi (2005) Role of phytochemicals on human health. *In* Proceedings of *National Seminar "Role of Medicinal and Aromatic Plants in Ayurveda, Unani and Siddha Systems of Medicine"* held on March 4-5, 2005 at CCS HAU, Hisar, 35-36.

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YSPUH&F, Solan

Chand, Romesh, R. Raina, Meenu Sood and Yash Pal Sharma (2004) Organic vs Inorganic farming of medicinal plants- some considerations**.** *In National Seminar on Intellectual Property Rights in Horticultural crops,* 12-13rd October, 2004, at UHF, Solan.

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Latha, A and M.A. Salam (2004) Variation in physiological and biochemical characters under soil moisture stress in cashew. In *Input use efficiency in Agriculture-Issues and strategies*, Nov 25-27, KAU, Vellanikkara, 13-14.

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Mini, S (2004) Coconut kernel protein and coronary heart disease. In *Agri-*

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HUMAN RESOURCE DEVELOPMENT

Education & Training

Name	Course	Date
Dr. G. Sridhar, Scientist (Plant Physiology)	Foundation Course for Agricultural Research Service (FOCARS), NAARM, Hyderabad	August 10 – December 7, 2004
Dr. Manish Das, Scientist Sr. Scale (Plant Physiology)	Recent Advances in Agricultural Research Project Management, NAARM, Hyderabad	May 27 – June 16, 2004
Mr. N. Srinivasa Rao, Scientist (Computer Application)	PERMISNet, IASRI, New Delhi	August 17-18, 2004
	ERNET training on Networking at ERNET India, New Delhi	September 6-11, 2004
	Implementation of the Global Plan of Action in India for the Conservation and Sustainable Utilisation of PGR for Food & Agriculture, NBPGR, New Delhi.	March 15-16, 2005
Mr. Saravanan Raju, Scientist Sr. Scale (Plant Physiology)	Patents Protection, New Delhi	February 8, 2005
	Science Citation Index, AAU, Anand	March 14, 2005
Mr. V. S. Parmar, AAO	Accounting Reforms, NIFM, Hyderabad	April 22-23, 2004

DISTINGUISHED VISITORS

- Dr. S.N. Batliwala, Secretary & Chief Accountant, Dhorabji Tata Trust, Mumbai on 20.5.2004
- Prof. K. P. Reddy, Director, IRMA, Anand on 30.5.2004
- Mr. Rajesh Umatt, CMO, Gujarat Life Sciences (P) Ltd., Baroda on 1.6.2004
- Mr. Mukesh Thakkar, AGM(DD),NABARD,Godhra on 20.7.2004
- Dr. R.P. Sharma, Project Director, PDP,Hyderabad on 30.9.2004
- Prof. I.L. Kothari, Professor, Department of Biosciences, SPU, V.V.Nagar on 8.10.2004 & 27.12.2004
- Dr. H. Minoo Parabia, Professor, Department of Biosciences, South Gujarat University, Surat on 12.10.2004
- Dr. S.V. Ngachan, Joint Director, ICAR Research Complex for Manipur Centre, Imphal on 25.10.2004 and 28.10.2004
- Mr. J.A. Solanki, MLA, Sarsa on 10.11.2004
- Dr. T.A.V. Murthy, Director INFLIBNET, Ahmedabad on 20.11.2004
- Dr. Mohd.Aslam, Addl.Director , Department of Biotechnology, New Delhi on 6.12.2004
- Dr. M.Heble, Retd.Scientist, BARC on 6.12.2004
- Prof. K. V. Peter, Vice Chancellor, Kerala Agricultural University, Trichur on 2.2.2005
- Dr. G. N. Qazi, Director, Regional Research Laboratory, Jammu on 2.2.2005
- Dr. K. V. Ramana, ADG (PC), ICAR, New Delhi on 2.2.2005
- Dr. O. P. Srivastava, Director, Institute of Agricultural Sciences, BHU, Varanasi, on 2.2.2005

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