वार्षिक प्रतिवेदन
ANNUAL REPORT 2003-2004

भाकृअनुप
ICAR

केन्द्रीय शुष्क बागवानी संस्थान

बीछवाल, बीकानेर – 334 006

Central Institute for Arid Horticulture

Beechhwal, Bikaner - 334 006 (Rajasthan) INDIA

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Preface by Director

The arid region is marked by weakness such as high temperature, low and erratic rainfall, low relative humidity, high PET, low soil fertility, etc. However, the region possesses strengths such as ample sunshine, abundant solar energy, low incidence of pests and diseases, etc. All this makes, the region most suitable for commercial production of horticultural crops for domestic and export market provide adequate technologies are adopted.

National Research Centre for Arid Horticulture came into existence on 1st April, 1993. This was later upgraded to Central Institute for Arid Horticulture in October, 2000.

The research and development work of the Institute is being carried out at CIAH, Bikaner and its regional station CHES, Godhra. Presently, a total of 21 research and development projects are under operation at main Institute and its regional station. In addition to this 3 National Agricultural Technology Projects are also under operation.

Over the years, institute has made a rich collection of biodiversity of major arid fruits and vegetables, released 8 varieties of arid vegetables which are popular among farmers of this region, standardized agrotechniques for cultivation of arid fruit and vegetables, standardized propagation techniques, production of vermicompost & its effect on plant production, adaptation mechanisms for drought tolerance in ber and arid vegetables, identified major diseases and development of IPM for their control is in progress. The Institute has also standardized a few technologies for production of value added products of arid horticulture produce.

The Institute is well equipped with several sophisticated equipments and during the period under report it has further strengthened its laboratories and field with the procurement of several equipments. The Institute is having well equipped ARIS Cell having computer systems, VSAT and Local Area Network.

I am pleased to publish this Annual Report for the year 2003-2004 which I am sure will be informative and useful to all those who are concerned with the agricultural scenario of this region.

(D.G.Dhandar)
Director

वार्षिक प्रतिवेदन सारांश

भूमिका

क्षमता एवं अक्षमता के समन्वय को समेटे हुए शुष्क पारिस्थितिक क्षेत्र भारत के कुल क्षेत्रफल के लगभग 12 प्रतिशत भूभाग में फैला है। यह क्षेत्र राजस्थान, हरियाणा, पंजाब, गुजरात, महाराष्ट्र, आन्ध्रप्रदेश तथा कर्नाटक राज्यों में है। यदि, कठोर जलवायविक परिस्थितियों के अनुकूल तकनीकियां यहां मिल जाती है तो, इस अद्‌भुत समन्वय के कारण इस क्षेत्र में बागवानी के अपार अवसर विद्यमान है। इस क्षेत्र को बागवानी बहुल क्षेत्र में बदलने से यहां की आर्थिक स्थिति, पोषण स्थिति एवं सामाजिक सुरक्षा के साथ–साथ रोजगार के अवसर भी सुलभ होंगे। इन्हीं उद्देश्यों को फलीभूत करने हेतु सन् 1993 में राष्ट्रीय शुष्क क्षेत्रीय उद्यानिकी अनुसंधान केन्द्र की स्थापना हुई जिसको सितम्बर, 2000 में क्रमोन्नत कर केन्द्रीय शुष्क बागवानी संस्थान में परिवर्तित कर दिया गया।

मुख्य ध्येय

- शुष्क एवं अर्द्ध शुष्क क्षेत्र की बागवानी फसलों का उत्पादन एवं उपयोग बढ़ाने के लिए तकनीकियां विकसित करने हेतु योजना लक्षित मूल अध्ययन करना।
- शुष्क एवं अर्द्ध शुष्क बागवानी फसलों के **'राष्ट्रीय जीन बैंक'** के रूप में कार्य करना।
- शुष्क एवं अर्द्ध शुष्क वातावरण में बहु–बागवानी फसलों का प्रभावी फसल–चक्र विकसित करना।
- शुष्क एवं अर्द्ध शुष्क बागवानी से संबंधित वैज्ञानिक सूचानाओं के **'राष्ट्रीय केन्द्र'** के रूप में कार्य करना।
- राज्य कृषि विश्वविद्यालयों तथा अन्य समान कार्य करने वाले संस्थानों के मध्य मुख्य समन्वयक की भूमिका के साथ शुष्क एवं अर्द्ध शुष्क बागवानी के **'मानव संसाधन विकास केन्द्र'** के रूप में कार्य करना।
- शुष्क एवं अर्द्ध शुष्क बागवानी के विकास एवं अनुसंधान के लिए मार्गदर्शी परामर्श उपलब्ध कराना।

उद्‌देश्य

1. शुष्क परिस्थितियों में बागवानी फसलों की जैवविविधता की पहचान कर उनका संग्रह, संरक्षण, मुल्यांकन तथा वर्गीकरण करना।
2. लक्षित फल–फसलों जैसे– बेर, अनार, आंवला, खजूर एवं खीरावर्गीय, फलीदार एवं फलदार (सोलैनीसियस कुल) सब्जियों को उपलब्ध जैव विविधता के प्रयोग द्वारा उच्च गुणवत्ता, उत्पादकता तथा जलवायु के अनुरूप विकसित करना।
3. यथा स्थापित एवं नवीन बागवानी फसलों में द्रुत प्रवर्ध्यगुणन से सम्बन्धित तथ्यों एवं उनकी बढ़वार तथा फल विकास की समस्याओं का अध्ययन करना।

4. पोषक तत्वों, जल एवं मृदा का बागवानी फसलों की शुष्क जलवायु के अनुरूप उत्पादकता बढ़ाने के लिए समुचित उपयोग करने की कृषि तकनीकियों का विकास कर उनका मानकीकरण करना।
5. उच्चताप एवं विकिरण संसाधनों के उपयोग हेतु बागवानी फसल–चक्र पद्धतियों के पारिस्थितिजन्य परिमापकों का अध्ययन करना।
6. शुष्क क्षेत्रीय बागवानी फसलों के उत्पादों की सर्वउपलब्धता हेतु कटाई उपरान्त तकनीकियों का विकास करना।
7. शुष्क परिस्थितियों में बागवानी फसलों हेतु समाकलित कीट एवं व्याधि प्रबन्ध की तकनीकियों का विकास करना।

कार्यकारी सारांश

केन्द्रीय शुष्क बागवानी संस्थान अपने क्षेत्रीय केन्द्र केन्द्रीय बागवानी परीक्षण केन्द्र, गोधरा (गुजरात) के साथ बागवानी फसलों के अनुसंधान एवं विकास कार्य के प्रति प्रतिबद्ध है। वर्ष 2003–2004 के मध्य अनुसंधान क्षेत्र में अर्जित महत्वपूर्ण उपलब्धियों का संक्षिप्त विवरण निम्नलिखित है :

जननद्रव्य संरक्षण

उत्तरांचल एवं पूर्वी उत्तर प्रदेश में किए गए सर्वेक्षण में बेर के 14 जननद्रव्यों का संग्रहण किया गया। बेर में पाला सहिष्णु प्रजाति के अध्ययन में छुआरा, टिकड़ी, काठाफल, खारिकी–1, बादामी, ग्लोरी तथा रोहतकसफेदा प्रजातियां पाले के प्रभाव से वंचित दर्ज की गई। अनार के अनारदाना प्रकार के 17 द्रव्यों का संग्रहण कर फार्म पर लगाया गया। इससे संचित कुल जनन द्रव्य संग्रह बढ़कर बेर में 338, अनार में 152, आंवला में 43, कैक्टर पीअर में 100, खजूर में 57, हो गया। इसी प्रकार सब्जी फसलों में काचरी में 68, मतीरा/तरबूज में 75, स्नेपमेलन में 65, मिर्ची में 45, खरबूजे में 60, लोकी में 20, ककड़ी में 10, बेंगन में 30, सेम में 20, तोरई में 20, तथा गलतोरई में 15 जननद्रव्य फसल–सुधार कार्यक्रम के लिए संग्रहित एवं संकलित किए गए।

शुष्क परिस्थिति में लोकी एवं तोरई के 20–20, गलतोरई के 25 एवं करेले के 04 संग्रहों का विश्लेषण करने पर विविधता की एक श्रृखंला दर्ज की गई। क्षेत्रीय केन्द्र गोधरा की अर्द्धशुष्क परिस्थिति में कद्दू (45 व 52), लोकी (20 व 26) एवं करेला (45 व 76) की वर्षा तथा गर्मी मौसम की फसलों में व्यापक विविधता दर्ज की गई।

आनुवंशिक सुधार

बेर किस्मों सी.आई.ए.एच. संकर–1 व सी.आई.ए.एच. चयन–1 के फलों की भण्डारण क्षमता का मूल्यांकन किया गया। यह देखा गया कि दोनों किस्मों के फलों को तौड़ाई के 4–5 दिनों तक साधारण कमरे के तापमान पर रखा जा सकता है।

तरबूज में मतीरे के शुष्क वातावरण वाले गुणों को समाहित करने के प्रयास में ए.एच.डब्ल्यू. 19 मतीरे की संतति एफ 6 का तरबूज की सूगरबेबी किस्म से मिलान करवाया गया। यह फलाकार, मिठास, गूदे की मात्रा व रंग, फल उत्पादन, कठोरता आदि गुणों में सामन्जस्य स्थापित करती दर्ज की गई।

इसके आधार पर एफ6/ए/10 संतति इनमें से सर्वाधिक उपयुक्त पायी गई। इनके अतिरिक्त लौकी की एएचएलएस राउण्ड 1, बैगन की एएचबी 2 एवं एफ 3, मिर्च की एचआरएम 1, तथा सेम फली की एएचडीबी 3 एवं 16 को आशानुकूल पाया गया। काचरी, सलाद काकड़ी, लौकी तथा बैगन की नव विकसित प्रजातियों की जॉच एवं मूल्यांकन कार्य किया गया।

अनार में अनुवांशिक सुधार कार्यक्रम में प्रति पौधा फल उपज, फला का वजन, फलों की संख्या आदि पहलुओं पर अध्ययन किया गया। इस प्रकार सर्वश्रेष्ठ किस्म का चयन करने में इन पहलुओं का अत्यधिक महत्व है।

ईरान, इराक, अफगानिस्तान तथा रूस के सद् तापमान से भारतीय शुष्क एवं अर्द्धशुष्क क्षेत्र में सीधे व्यावसायिक स्तर पर उत्पादन हेतु लाई गई अनार की किस्में पूर्ण रूप से असफल रहेंगी क्योंकि इनके पौधे पतझड़ अवस्था में रहते हैं।

शुष्क पारिस्थिति में अनार में फल फटना एक गम्भीर समस्या है। एक अध्ययन में पाया गया कि मृगबहार फसल व्यावसायिक किस्मों में 50–80 प्रतिशत तक फल फट जाते हैं। उच्च तापमान के कारण अनार के पौधे में ऋतुचक्र बदल जाता है। इससे इसकी सभी कियाएं असमय होती है और उपज न्यूनत्तम हो जाती है। कुछ एकल पौधों (एफ 1, डीकेएस/एच/97/003) ने इस जलवायु में अच्छे परिणाम दिए हैं।

वानस्पतिक प्रवर्धन

आवलां, अनार, लसोड़ा तथा इमली में प्रवर्धन अध्ययन प्रारम्भ किया गया है। बड़े आकार (25x15सेमी.) पॉलीथील थेली में बीजांकुरण अच्छा पाया गया। तालाब की मिट्टी में मींगनी की खाद मिलाकर भरी गई थेलियों पौध बढ़वार सबसे अच्छी प्राप्त की गई।

अनार में प्रवर्धन अध्ययन में पाया गया कि जनवरी–मार्च तथा जुलाई–अगस्त के दौरान ली गई अर्द्ध कठोर कलमें सर्वोत्तम परिणाम देती है। लसोड़ा में 15 अगस्त के आसपास की गई बडिंग ने उत्तम परिणाम दिए।

विकास एवं प्रगति

मतीरा तथा तरबूज के विकास एवं प्रगति अध्ययन में दर्ज किया गया कि यदि तरबूज में सिंचाई कम से कम करें तो उस पर विपरीत प्रभाव पड़ता है जबकि मतीरा इस स्थिति में भी अच्छा रहता है। 22 फलों में प्रकाश संश्लेषण परिमापकों का अध्ययन किया गया। इसमें देखा गया कि सूखा सहिष्णु गुण तथा प्रकाश संश्लेषण किया एक दूसरे से जुड़े हुए है।

खीरावर्गीय फसलों में सूखे के परिमापकों को निश्चित करने के अध्ययन में पाया गया कि पौधों में बढ़त का दबाव एवं सूखे की स्थिति का दबाव दोनों प्रकारों को प्रयोग में लाया जा सकता है।

एकीकृत जल एवं पोषण प्रबन्ध

अनार में भेड़ की मीगनी, गोबर खाद, वर्मीकम्पोस्ट तथा अकार्बनिक उर्वरकों के साथ नत्रजन, पोटाश,

फास्फोरस की मानक मात्रा दी गयी। वर्मीकम्पोस्ट व अकार्बनिक उर्वरक देने पर पौधे की ऊंचाई, बढ़त, उपज तथा फल भार में बढ़ोतरी दर्ज की गई। इससे भूमि की उर्वरा शक्ति में भी वृद्धि देखी गयी। चीकू व आंवला की पत्तियों का नमूना डीआरआईएस मानक विकसित करने के लिए विश्लेषित किया गया।

फसल विविधता अध्ययन

आंवला आधारित बहुस्तरीय फसल प्रणाली में बैगन के पौधे में पलवार बिछाने पर उसकी बढ़वार, विकास, उपज, तथा जलताप प्रभाव का अध्ययन किया गया। काली पॉलीथीन की पलवार बिछाने पर पौधे का चहॅमुखी विकास दर्ज किया गया। इससे जल व मृदा क्षरण पर भी अंकुश लगता देखा गया। बहुस्तरीय फसल प्रणाली में आंवला–बेर–बैगन–मोठबीन–कुमिन आधारित प्रणाली से सर्वाधिक आय प्राप्त की गयी।

पौध संरक्षण

बेर में फल मक्खी तथा फल बेधक कीटों की रोकथाम के लिए फेनवलरेट (0.005 प्रतिशत) अथवा डेल्टामिथरीन (0.0015 प्रतिशत) के घोल का 21 दिनों के अन्तराल पर एवं इसके बाद एनएसकेइ (5 प्रतिशत) के दो छिड़काव प्रभावी अंकित किए गए। इसके अतिरिक्त अन्य प्रकार के फसल कीटों के नियंत्रण के उपायों पर अनुसंधान कार्य प्रगति पर है।

बेर में चूर्णी फफूंद रोग पर तदर्थ योजना के अंतर्गत चूर्णी फफूंद रोग का विभिन्न अवस्थाओं में बेर पौधे पर सहिष्णुता का अध्ययन किया गया। यह रोग अलग–अलग जननप्रकारों में अलग–अलग प्रकार से प्रभावी अथवा अप्रभावी देखा गया।

पौध उत्पादन

संस्थान के बीकानेर स्थित फार्म पर दो हेक्टेअर क्षेत्र में विभिन्न शुष्क क्षेत्र फल वृक्षों लगा कर एक **प्रक्षेत्र संग्रहालय** तैयार किया गया है। इसमें देश– विदेश के 60 से अधिक प्रजातियों के फल–वृक्ष तथा 21 जिनेरा संग्रह कर लगाए गए हैं।

वानस्पतिक प्रवर्धन के द्वारा बीकानेर फार्म पर बेर, आंवला एवं अनार के कुल 15000 पौधे तैयार किए गए। मतीरा, फूटककड़ी, काचरी ,ककड़ी, टिण्डा तथा चवला का बीज उत्पादित कर किसानों को विक्रय किया गया। इसी प्रकार संस्थान के क्षेत्रीय केन्द्र गोधरा (गुजरात) पर बेर, आंवला,अनार, सीताफल, आम,चीकू, फालसा,जामून, अमरूद, नीबू, आदि के लगभग 12000 पौधे बनाकर किसानो को विक्रय किए गए। इसके अतिरिक्त इस केन्द्र पर भिण्डी के 35, चवला के 60 तथा अन्य सब्जियों के 108 कि.ग्रा. बीज तैयार कर बेचे गए।

उपजोपरान्त प्रौद्योगिकी

इसके अन्तर्गत खेजड़ी की फलियों को सुखाकर **सांगरी** बनाने के लिए फलियों को तौड़ने की अवस्था एवं

सुखाने की सही स्थितियों का मानकीकरण करने का प्रयोग आरंभ किया गया। सुखाने की ट्रे में फलियों को सुखाने से मात्रा तथा गुणवत्ता दोनों सही रखी जा सकती है।

काचरी को सुखाने की विधि का मानकीकरण करने के लिए किए गए प्रयोग में पाया गया कि छिलके सहित सुखाए गए फलों में पोषक तत्वों की मात्रा छिलके रहित सुखाने पर अधिक प्राप्त की गई है।

कृषि–विस्तार गतिविधियां

शुष्क बागवानी की शोधित तकनीकी' विषय पर दिनांक 21.08.03 को एक दिवसीय प्रशिक्षण कार्यक्रम का आयोजन किया गया। इसके अतिरिक्त इस अवधि के दौरान लगभग 679 किसानों /छात्रों ने संस्थान का भ्रमण कर नई जानकारियां प्राप्त की। 24.02.04 को आयोजित राज्यस्तरीय किसान मेले में सक्रिय भाग लिया।

वित्त प्रबन्ध

वर्ष 2003–2004 के दौरान योजना मद में 121.90 लाख रूपए आंवटित किए गये थे जबकि गैर–योजना मद में 246.00 लाख रूपयो का आंवटन था। इस अवधि में संस्थान ने आंवटित राशि का पूर्ण व्यय योजना के अनुसार किया।

Executive Summery

Central Institute of Arid Horticulture, Bikaner alongwith its one regional station CHES, Godhra (Gujarat) is devoted towards the Research and Development work on arid and semi arid horticultural crops. Following are the highlights of the research achievements of the Institute for the year 2003-2004:

Germplasm conservation

During the period under report the survey of ber germplasm was undertaken and 14 genotypes were identified from Uttaranchal and Eastern U.P. Screening of ber cultivars for frost resistance demonstrated that cvs. Chhuhara, Tikkadi, Kathphal, Khariki No. 1, Badami, Glori, Safeda Rohtak were unaffected by frost. In pomegranate, 17 anardana types were collected and planted in the field. With this, a total of 338 germplasm of ber, 152 of pomegranate, 43 of aonla, 100 of cactus pear, 57 of date palm is now available at the Institute. The germplasm of vegetable crops comprised of mateera/ watermelon (65), roundmelon (10), muskmelon (60), snapmelon (65), kachri (68), bottlegourd (20), kakdi (10), ridgegourd (20), sponge gourd (15), chilli (45), brinjal (30) and beans (20) have been maintained for use in crop improvement programme.

Under arid conditions, 20 accessions of bottlegourd, 20 of ridge gourd, 25 of sponge gourd and 04 of bitter gourd were characterized and wide range of variability was recorded.

As a rainy and summer season crop germplasm evaluation of pumpkin (45 & 52), bottlegourd (20 & 26) and bitter gourd (45 & 76) a wide range of variability was recorded under semi arid conditions at CHES, Godhra.

At CHES, Godhra, the germplsm evaluation of Aonla, Sapota, Wood apple, Jamun, Tamarind, Bael, Mahua is in progress.

Genetic improvement

The shelf life of CIAH-Sel 1 and CIAH-H-1 was evaluated at Bikaner. It was observed that both the lines could be kept at room temperature for 4-5 days after harvest.

In a pursuit to incorporate drought hardy characters of mateera in water melon, F6 progenies of Mateera AHW 19 × Sugarbaby were evaluated and found to be promising with respect to fruit yield, fruit size, flesh content, colour, firmness and TSS.

On the basis of quality and yield characters, the advanced progeny [F_6/a/10] Mateera AHW 19 x Sugarbaby, has been found most potential. Besides, AHLS Round-1 in bottlegourd, AHB2 and F_3 of AHB4×PPC in brinjal, HRM 1 in chilli, AHDB3 and AHDB16 in Indian bean and AHG 13 in cluster bean were found promising.

Released as well as newly developed varieties of kachari, salad kakdi, bottle gourd, round melon, brinajal were tested to assess the yield potential over the seasons.

On the basis of the analysis of component of variability, it is evident that number of fruits per plant, fruit yield per plant, fruit weight and weight of 100 arils deserves due weightage while formulating selection strategies for improvement in pomegranate. Thus, selection of superior types based on fruit yield components would be effective after ensuring the acceptable fruit quality components in the breeding material.

Introduction of pomegranate cultivars from mild temperature regions (Iran, Iraq, Russia, Afghanistan) for direct exploitation as a commercial variety in arid and semi arid regions of India would be completely failure because they behave like deciduous.

Seed hardiness is a varietal character and attempts must be made to breed varieties with softer seeds. Seed hardiness is a dominant character.

Fruit cracking is a serious problem under extreme of arid environment. Studies reveal that all the commercial varieties/progenies depicted severe fruit cracking (50-80 %) as a *Mrig bahar* crop. High temperature conditions (>38^{0}C from March to October) limits the period of crop harvesting under hot arid condition with the manipulation in crop regulations and badly affected the aril colour, softness and quality of fruits. The pigment anthocyanin content is generally of lower order in fruits harvested between April to August in comparison of higher level in the fruits harvested in between November to January.

Some individuals of F_1 progeny (DKS/H/97/003) of desirable parental combination exhibited encouraging results for the highest fruit quality (sweet, soft, bold and dark red arils) and yield under the extremes of arid environment.

Vegetative propagation

Studies on propagation of aonla, lasoda, pomegranate and tamarind have been initiated. In aonla, seed germination was better in bigger size (25×15cm) polybags. The vigour of seedlings was better when pond soil and manures were used as filling mixture.

Studies on propagation in pomegranate conducted at Bikaner revealed that semi hard wood cuttings taken during July-August and January-March gave best results. In lasoda, it was observed that budding around 15th August gave best performance.

Growth and development

Studies on growth and development in mateera and watermelon demonstrated that imposition of water stress drastically reduced biomass production in watermelon but not in mateera. Studies on

photosynthetic rate and associated parameters in 22 fruit species demonstrated that drought tolerance was correleated with photosynthatic rate and stomatol conductance.

Screening of parameters for drought in cucurbit reveals that plant height stress index, dry matter stress index and leaf rolling can be used for screening of germplasm.

Integrated nutrient and water management

The recommended doses of N, P and K were applied through sheep manure, cattle manure, vermicompost and inorganic fertilizers to the pomegranate. The N, P & K nutrient requirements were given through either 100% through each manure or in 50:50 ratio of two types of sources. An indepth studies were undertaken and it was found that plant growth, fruit weight, fruit yield were better when vermicompost and inorganic fertilizers were applied in equal quantities. Similarly, the soil fertility build up was also good when vermicompost and inorganic fertilizers are applied in equal ratio.

To develop DRIS norms, the leaf sampling was done in Sapota and aonla and samples analysed.

Crop diversification studies

In aonla based multistorey cropping system, effect of mulching on growth, development, yield and hydrothermal regimes were studied in brinjal. It was observed that plant height, stem girth, biomass, plant spread and fruit yield was maximum with black polythene mulch. Similarly, black polythene mulch gave better soil water retention.

The biomass productivity was recorded maximum in brinjal followed by mothbean, saji and cumin under different cropping models. The highest economic return was obtained in model comprised of Aonla-Ber-Brinjal-Mothbean-Cumin.

Plant protection

Effective isolates of biagents (CIAH-196 of *P. fluorescens* and CIAH-240 *Trichoderma*) were tested with different treatment combinations under orchard condition. It was observed that 5% of *P. fluorescens* combined with half dose of recommended dose of karathane resulted 59.5% control efficacy.

Application of either fenvalerate (0.005%) or deltamethrin (0.0015%) at 21 day interval followed by two application of NSKE (5%) at 10 days interval was found to be effective in reducing the incidence of both fruit fly and fruit borer infesting ber.

In an Ad-hoc scheme on ber powdery mildew, electrophoretic variations in ber germplasm with different level of resistance to powdery mildew were evaluated. It was found that genotypes can be differentiated on the basis of electrophoretic profiles. Biochemical indices like total protein and

calcium contents were studied in ber genotypes varying in their resistance as biochemical markers for powdery mildew screening.

Plant production

At Bikaner, two-hectare area has been developed as field repository by planting different arid fruits. So far, 60 varieties/strains of different fruit trees accommodating 21 genera have been collected from different places in India and abroad.

The fruit trees like ber, aonla and pomegranate were multiplied through vegetative propagation at Bikaner and a total of 15,000 plants were produced. Besides, seed production of about 150 kg. of different vegetable crops like mateera, snapmelon, kachri, kakdi, tinda and clusterbean for distribution to the arid zone farmers was under taken. At CHES, Godhra a total of 12,000 planting material of ber, aonla, pomegranate, custard apple, mango, sapota, phalsa, jamun, guava and kagzi lime were propagated and supplied to farmers and developmental agencies. In addition to this the seeds of Bhindi (35kg), clusterbean (60 kg) and other vegetables (108 kg) were produced and supplied to farmers from CHES, Godhra.

Post harvest technology

An experiment was carried out to standardize optimum stage and suitable conditions for dehydration of khejri pods. It was observed that highest recovery per cent was obtained in blanced pods dried in tray drier.

An experiment was carried out to standardise the dehydration of kachari. It was observed that nutrient content was on higher side in fruits dried along with peel.

Agricultural extension

A training programme on "Innovative techniques of arid horticulture" was organized on 21.08.2003. Besides this, 679 farmers/students visited institute and institute took active part in state level Farmers Fair on 24.02.2004.

Finances

The budget allocation during 2003-2004 under plan was 121.90 lakhs were as under non-plan it was 246.0. The Institute was able to utilized the allocated fund.

Introduction

The arid ecosystem, which is spread over nearly 12 per cent of the land area in the states of Rajasthan, Gujarat, Haryana, Punjab, Andhra Pradesh, Karnataka and Maharashtra has blend of strengths and weaknesses. This provides ample opportunity to develop this zone into a horticulture bowl of India, provided adequate technologies to harness the strengths are developed. The conversion of this region into horticultrally productive area will provide income, nutrition security and help in employment generation in the region. With this view, the NRCAH was established in 1993 which was later upgraded to CIAH in September 2000.

Mandate

1. To undertake basic and strategic studies for developing technologies to enhance productivity and utilization of arid and semi-arid horticultural crops.
2. To act as national gene bank of arid and semi-arid horticultural crops.
3. To develop the multistory horticulture based sustainable cropping system under arid and semi-arid environment.
4. To act as national repository of scientific information related to arid and semi-arid horticulture.
5. To coordinate network research with State Agriculture Universities and line departments and act as centre for Human Resource Development in arid and semi-arid horticulture.
6. To provide consultancy in research and development of arid and semi-arid horticulture.

Mission/objectives

*To introduce, collect, characterize, conserve and evaluate the biodiversity of horticultural crops under arid and semi-arid environment.

*To utilize the available biodiversity and improve the target fruit crops such as ber, pomegranate, aonla, date palm and cucurbitaceous, leguminous and solanaceous vegetables to develop high quality and productive types having tolerance to biotic and abiotic stresses.

*To study the factors related to rapid multiplication of propagules in case of established as well as new crops and the problems related to their growth and fruit development.

*To standardize agrotechniques with respect to efficient use of soil, water and nutrients for

increased horticultural productivity involving water harvesting and conservation techniques under rainfed conditions, efficient use of the scarce irrigation water and nutrient management.

*To study the ecophysiological parameters of cropping system models for utilization of high temperature and radiation resources.

*To develop postharvest technology package for extended use of the horticultural produce of arid and semi-arid region.

*To develop integrated pest and disease management technologies for horticultural crops under arid environment.

The salient research achievements of the Centre during 2003-2004 were:

1. During the period under report 14 genotypes of ber were identified from Uttranchal and Eastern UP. With this, a total of 338 germplasm of ber, 152 of pomegranate, 43 of aonla, 100 of cactus pear, 57 of date palm are being maintained in field gene bank. The germplasm of vegetable crops comprised of mateera/ watermelon (65), roundmelon (10), muskmelon (60), snapmelon (65), kachri (68), bottlegourd (20), kakdi (10), ridgegourd (20), sponge gourd (15), chilli (45), brinjal (30) and beans (20) have been maintained for use in crop improvement programme. During the period mateera and snapmelon germplasm was regenerated for the maintenance and a set of all the accessions has been deposited in NGB, NBPGR, New Delhi for long term conservation.

2. Studies on frost resistance in ber revealed that cvs. Chhuhara, Tikadi, Kathaphal, Kharki No.1, Badami, Glori, Safeda Rohtak were unaffected by frost.

3. The shelf life of CIAH-Hyb1 and CIAH-selection 1 was evaluated and it was observed that both the lines could be kept at room temperature for 4-5 days after harvesting.

4. The germplasm of potential gourd cucurbits such as bottlegourd, ridgegourd, sponge gourd and bittergourd has been characterized for agromorphological and yield contributing characters.

5. On the basis of quality and yield characters, the advanced progeny [F_6/a/10)] mateera AHW 19 × Sugarbaby, has been found most potential. Besides, AHB2 and F_3 of AHB_4 × PPC in brinjal, HRM-1 in Chilli, AHDB3 & AHDB16 in Indian bean were found promising. AHLS-Round-1 in bottlegourd, AHSB-1 of sword bean, AHC-13 cluster bean were found most promising.

6. The pomegranate hybrid developed at Bikaner. DKS/H/97/003 depicted excellent fruit quality parameter e.g. soft, bold and red aril having TSS around 20° Brix.

7. The micropropagation technique in *Capparis decidua* was standardised.

8. In lasoda budding around 15th August gave best performance.

9. The correlation between yield and yield attributing parameters in ber were worked out.

10. Corrlation between photosynthetic rate and associated parameters revealed that drought tolerance was corrleated with photosynthetic rate and stomotal conductance.

11. Application of organic manure and inorganic fertilizer were compared in pomegranate. It was observed that plant growth parameters and WUE were best under vermicompost or vermicompost+inorganic fertilizer. Vermicompost either alone or in combination with inorganic fertilizer improves N, K content and water holding capacity of soil.

12. Effective isolates of biagents (CIAH-196 of *P. fluorescens* and CIAH-240 *Trichoderma*) were tested with different treatment combinations under orchard condition. It was observed that 5% of *P. fluorescens* combined with half dose of recommended dose of karathane resulted 59.5% control efficacy.

13. The scientists of the centre took active part in Kisan melas and other extension activities and acted as resource persons for various training programmes and as faculty to teach courses in RAU.

14. In aonla based multistorey cropping system, effect of mulching on growth, development, yield and hydrothermal regimes were studied in brinjal. It was observed that plant height, stem girth, biomass, plant spread and fruit yield was maximum with black polythene mulch. Similarly, black polythene mulch gave better soil water retention.

15. The technique for dehydration of *Prosopis cineraria* pods was standardized.

Germplasm conservation

Mission A: Introduction, collection, characterization, conservation and evaluation of horticultural biodiversity.

At CIAH, Bikaner

A 1. Introduction, collection, characterization, conservation and evaluation of arid fruits under hot arid environment

A 1.1 Introduction, collection, characterization, conservation and evaluation of *Ziziphus* species

Status of ber Germplasm

At present 338 genotype/strains of ber are maintained in the National Repository of CIAH, Bikaner.

Survey and collection of ber germplasm

Name of the state	Area covered	Year	Number of collection
Rajasthan	Chirana	1997	04
	Jobner	1997	01
	Bhusawal	1997	10
	Udaipurvati	1997	02
	Banar	1997	02
	Jodhpur	1995	01
	Jodhpur	1997	08
	Jodhpur	1998	10
	Borunda and Garsurya	1998	04
	Booda kila	1998	01
	Khawaspura	1998	04
	Bikaner	1998	03
	Sirohi	2000	04
Gujrat	Patan	2000	03
	Mehsana	2000	03
	Anand	2000	02
	Panchmahal	2000	02
	Sabarkata	2000	01
Andaman	-	2001	04
Uttranchal		2003	10 +4*
Uttar Pradesh		2003	10 + 4*
		Total	89

* Genotypes collected from Uttranchal and Uttar Pradesh do not survive

Collection of ber genotypes from Uttranchal and Uttar Pradesh

Two survey were undertaken for the identification of the elite plants of ber from Uttranchal and Eastern Uttar Pradesh. During the exploration of Uttranchal 14 genotypes were identified. Out of that 06 were *Ziziphus mauritiana* types, 03 were *Ziziphus nummularia* and 05 were *Ziziphus species*. Among the five *Ziziphus* species identified from the Uttranchal one specific strain was identified as climbing ber in the forest of the Khatima Tanakpur road. In the survey of Eastern Uttar Pradesh another 14 genotypes were identified out of which two were Ziziphus species and 12 were *Ziziphus mauritiana* types. The bud wood of identified genotypes was collected and budded in-situ for further evaluation between July to August 2003. Out of 28 collections, 20 genotypes are surviving in the field. The bud wood of rest 8 genotypes will be collected in August 2004.

Study the effect of low temperature and frost

A study was undertaken to assess the effect of low temperature and frost on vegetative growth pattern, extent of damage, recovery in final stage and estimated yield loss. The ber cultivars Chhuhara, Tikadi, Kathaphal, Badami, Kharki No-1 and some species viz. *Zizyphus nummularia* and *Z. rotundifolia*, Chinese jujube were not affected by the frost. However, cultivars Gola, Seb and Umran were affected mildly, whereas Mundia, Kaithali Bagwadi, Rashmi, Aliganj, Maharwali and Dandan were moderately affected. Further, the estimated yield loss was maximum in cultivar Dandan (40%), and Bagwadi (40%) and the recovery with respect to plant growth and yield was partial. However, the complete recovery was recorded in the cultivars like Gola, Seb, Mundia, Umran and Kaithali. The yield loss in ber varieties was because of the fact that most of the varieties attain harvesting stage during the period of frost occurrence.

Study of floral biology in ber

Observations with regards to flower initiation (peak and end), number of flower per clusters and fruit set period (initiation, peak and end) were recorded in germplasm collected through exploration of Gujarat and part of Rajasthan.

Fruit fly resistance in ber

Observations with regard to fruit fly tolerance/resistance among the cultivars/ genotype were recorded during the period under report. The cultivers Gola, Seb, Kaithali, Banarsi Karaka, Sanaur-5, Banarsi Peondi etc. showed more susceptability in comparison to Illaichi, Katha and Umran. The study needs in depth study combining several others parameters so as to arrive a definite conclusion regarding the ability of cultivar's resistance against fruit fly.

Varietal evaluation with respect to plant growth and yield attributes

Observations were recorded with respect to plant height, spread, diameter, pruned wood weight, size of leaf, length of petiole, average fruit weight, fruit size, pulp thickness, stone weight, stone size, TSS etc of commercial cultivar of ber. It was observed that the maximum fruit weight was in Umran (54g) followed by Seb (45g) and Gola (43g). The TSS was maximum in Reshmi 24% and minimum in Thornless (16%). The pulp thickness was maximum in Seb (1.7cm) followed by Gola (1.5cm) and minimum in Dandan (0.8cm) and Illaichi (0.8cm).

Characterization and evaluation of ber genotypes collected from Gujarat and part of Rajasthan:

Observations were recorded with respect to plant height, canopy spread, scion diameter, root stock diameter, besides size of leaf, length of petiole etc of 15 ber genotypes collected from Gujarat and part of Rajasthan.

Characters	Range		
Plant height (m)	2.0	to	3.75
Canopy spread (m)	2.5×2	to	5.5×5
Scion diameter (cm)	3.5	to	7.5
Leaf size (cm)	2.1×2	to	9.2×6.4

Further, during the reported period highest fruit yield was recorded in the AKS/DKS/NRCAH 40 (IC 322121) i.e. 25 kg per plant. The average fruit weight (24g), fruit size (4.3×3.2 cm), was recorded in IC322121. Seedling plants are surviving well in the field of 04 genotypes collected from Andaman.

Study on level and severity of pruning in ber cv Kaithali

An experiment was conducted with three different levels of pruning (25%, 50%, & 75%) and four timing (20 April, 30 April, 10 May and 20 May) in RBD design, replicated thrice. The observations were recorded with respect to number of days taken to sprout initiation, profuse sprouting, plant growth characteristics (height, spread and diameter), weight of pruned wood, fruit yield, fruit size, fruit weight, stone size, stone weight, pulp thickness, total sugar, ascorbic acid, and protein content, photosynthetic activity, light interception etc. Among all the treatment combinations pruning with 50% intensity in the month of mid April gave better response in respect to plant growth and fruit yield (Table 1-3 & Fig. 1-2).

Evaluation of *Ziziphus rotundifolia*

22 strains of *Ziziphus rotundifolia* were evaluated for their morphological characters.

Table 1. Effect of pruning intensity and time on plant growth

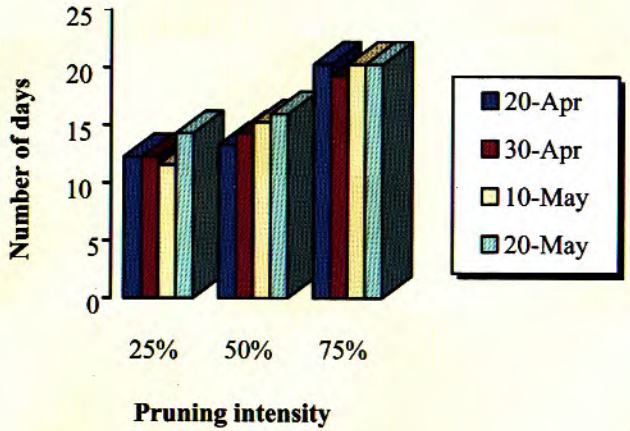
Treatments	Plant Height (m)					Canopy Spread (m)					Stem Diameter (cm)				
Time / Intensity	20th April	30th April	10th May	20th May	Mean	20th April	30th April	10th May	20th May	Mean	20th April	30th April	10th May	20th May	Mean
25%	4.30	3.58	3.92	3.90	3.93	5.44	4.81	5.50	6.00	5.44	17.30	14.27	12.00	13.60	14.29
50%	4.30	4.17	4.08	3.67	4.06	6.58	5.26	5.90	6.04	5.95	16.70	12.10	13.30	14.03	14.03
75%	3.58	3.25	3.58	3.60	3.50	5.96	5.15	4.33	5.34	5.19	12.03	11.33	08.83	11.47	10.91
Mean	4.08	3.67	3.86	3.72	3.83	5.99	5.07	5.24	5.79	5.52	15.34	12.56	11.37	13.03	13.07

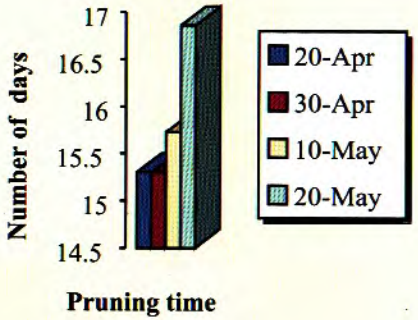
Table 2. Effect of pruning intensity and time on number of primary/secondary/tertiary shoots

Treatments	Primary shoots					Secondary shoots					Tertiary shoots				
Time / Intensity	20th April	30th April	10th May	20th May	Mean	20th April	30th April	10th May	20th May	Mean	20th April	30th April	10th May	20th May	Mean
25%	4.25	4.00	3.75	3.66	3.91	5.00	5.00	4.66	4.66	4.83	6.00	6.00	5.33	6.00	5.83
50%	4.00	3.66	3.33	2.00	3.24	7.00	7.00	6.00	6.66	6.66	8.00	8.00	7.00	7.33	7.58
75%	2.33	2.33	1.66	1.86	2.05	6.00	5.66	5.66	5.00	5.58	6.66	6.00	6.33	6.33	6.31
Mean	3.53	3.33	2.91	2.50	3.06	6.00	5.88	5.44	5.44	5.69	6.88	6.66	6.22	6.55	6.57

Table 3. Effect of pruning intensity and time on fruit yield (Kg/ tree)

Treatments	Fruit Yield				
Time / Intensity	20th April	30th April	10th May	20th May	Mean
25%	26.00	22.00	16.00	17.00	20.25
50%	30.00	27.00	19.00	18.00	23.50
75%	22.00	18.00	15.00	14.00	17.25
Mean	26.00	22.33	16.66	16.33	20.25





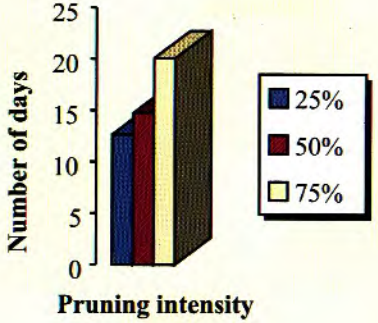
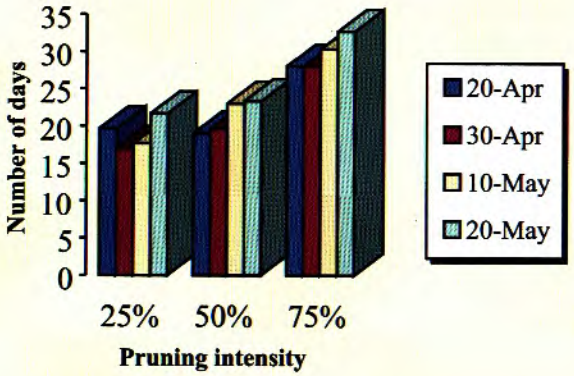
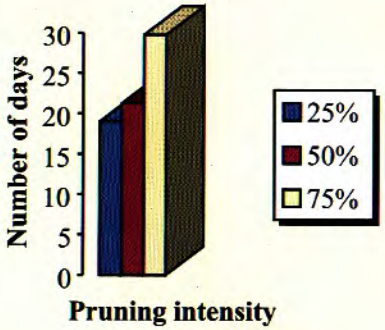


Fig : 1 Effect of pruning intensity and time on number of days taken to sprout initiation





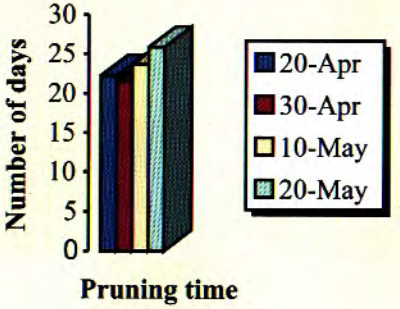


Fig : 2 Effect of pruning intensity and time on number of days taken to profuse sprouting

A 1.2 Introduction, collection, characterization, conservation and evaluation of pomegranate (*Punica granatum L.*) under hot arid environment

During the year, pomegranate germplasm (152) were maintained and evaluated for growth, yield and quality. Fifty six genotypes were found deciduous and rest were found evergreen type. The height of plant varied from 1.20-2.90 m. Average weight of fruit 205g and TSS 20.2^0 brix was recorded in cv. Ganesh.The performance of Jalore seedless was also found better with respect to crop load and quality of fruits. The maximum size of fruit was in cv P-26 (8.0×7.3 cm) followed by in Ganesh (7.95 × 6.80 cm). Highest TSS (21.4^0 brix) of fruit was recorded in cvs.G-137 and Jalore seedless. Under germplasm evaluation, it was observed that maximum genotypes produced cracked fruits. The extent of fruit cracking varied within the genotypes and season of fruiting.

Three elite type (progenies) from seedling populations were transplanted in the field for evaluation. Anardana types (17) were planted in the field and evaluated. Survival of seedlings was better. Few genotypes started flowering during the year however, fruit set was not observed.

A. 1.3 Introduction, collection, characterization, conservation and evaluation of Date palm (*Phoenix dactylifera* L.) under hot arid environment.

Survey and Collection of germplasm

Fifty seven date palm varieties/genotypes including exotic germplasm were maintained in repository. The offshoots of five varieties were collected from Date palm Research Centre, G.A.U., Mundra ,(Gujarat). The offshoots were treated with IBA 1000 ppm and Bavistin 0.2 % before planting in the germplasm block. Suckers of earlier identified genotypes were also collected from farmers field of Kachchh region. Two elite type sucker of date palm was collected from GAU, S.K.Nagar. Date palm cvs. Khalas, Degletnoor, Thoory and Khairpur were collected from R.F.R.S.,Abohar, Punjab and were planted in the germplasm block for evaluation.

Evaluation of germplasm

Under germplasm evaluation, mortality in newly planted suckers were observed. The palm height varied from 2.0-4.5 m at an age of five years. Spathe emergence was initiated in twenty genotypes from middle of the February and completed in second week of March. Flowering and fruiting was recorded in cvs. Halawy, Zahidi, Dayari, Shamran, Khadrawy, Medini, Sadami, Muscat, Khuneizi, Hayani Sewi, Medjool, Bikaner local, Umshok,Hamara, Sayer, Sabiah, Chip chap, Braim and Tayer. Late emergence of spathe (first week of March) was recorded in Zahidi, Chipchap, Briam,

Sewi, Shamran, and Tayer. First time spathe emergenece was recorded in exotic cultivar Braim introduced from Iraq during the year 1998. The spathe opening was also earlier in those varieties in which emergence of spathe was earliest. However, Halawy, Dayari, Shamran and Zahidi produced spathes and fruiting during both the years (2002 and 2003). In some genotypes low fruiting was observed in second year of fruiting.

The average number of bunch/palm varied from 01 (Zahidi and Chip chap) to 09 (Halawy, Dayari) during the year of fruiting. On an average 04 bunch/palm were recorded in Hamara, Sadami, Sewi and Medini cultivars. Maximum bunch length was 92 cm in Halawy followed by Dayari (85.6 cm) while minimum (28 cm) was in Hayani. Number of fruits per strand varied from 5.0 (Hamara) to 25.0 (Bikaner local) followed by Zahidi(20). The initiation of doka stage was early in variety Halawy and Muscat followed by Braim Chipchap, Shamran, Khuneizi, Tayer, Dayari, Sadami and Medini while late doka was recorded in Medjool. Maximum average weight of fruit 9.25 g was recorded in Dayari while 5.6 to 8.6 g weight of fruit was recorded in other cultivars. Biggest size (4.90 × 3.30 cm) fruits was observed in Medjool followed by Dayari in comparison to other genotypes. The size of fruits varied from 2.82 to 4.90 cm. in length and 1.60 to 3.30 cm in width during the year. Stone weight varied from 0.56 to 1.25 g (Table-4).

Varietal Evaluation

For the development of a block of promising date palm cultivars, the offshoots of Halawy, Khalas, Zahidi, Medjool, Shamran and Khadrawy were planted and maintained. Survival of plants reveals that high mortality of plants was recorded in Medjool and Halawy which may be due to several reasons and affecting factors. Earlier planted varieties Halawy, Zahidi, Medjool and Khalas started flowering and fruiting after five years of planting. Two to three bunch/palm were harvested during the year. However, maximum palms are under vegetative growth stage.

Evaluation of Tissue culture plants

Eight varieties of tissue culture plants (Dhamas, Khasab, Khalas, Khuneizi, Nubsully, Yakoobi, Fard and Nagal) were maintained and evaluated for growth and flowering and fruiting under arid conditions. Better vegetative growth was recorded in all varieties. On an average more than 1.5-2.5 m height of plant was recorded after five years of growth. However, flowering and fruiting was observed only in Dhamas cultivar. The size of bunch was small. Berry colour was yellow and sweet in taste, however, stone size was medium in weight.

Table 4. Spathe emergence/flowering and fruit characters of date palm germplasms under hot arid conditions during 2003.

S. No.	Cultivars/ genotypes	Spathe emergence		Bunch per palm			No.of strand/ bunch	No.of berry/ strand	Weight of fruit (g)	Fruit size (cm)		Dokla stage of maturity	Stone size		
		Emergence	Opening	No.	Length (cm.)	Av. bunch Weight (Kg)				Length	Weight		Weight (g)	Length (cm)	Width (cm)
1	Halawy	15.02.03	01.03.03	8.5	92.0	2.80	37.5	18.5	7.85	3.33	2.40	08.7.03	0.90	2.20	0.90
2.	Khadrawy	18.02.03	12.03.03	7.0	56.6	3.00	26.7	14.3	7.42	3.23	2.15	22.7.03	0.76	1.70	0.83
3.	Shamran	22.02.03	13.03.03	3.0	75.3	3.00	28.5	18.3	8.30	3.33	2.10	22.7.03	0.74	1.70	.083
4.	Zahidi	01.03.03	15.03.03	1.0	35.0	3.00	21.0	20.0	7.25	3.00	2.16	23.7.03	0.86	1.90	0.90
5.	Braim	02.03.03	19.03.03	4.0	45.0	3.00	21.0	15.0	7.74	3.34	2.10	20.7.03	1.09	2.00	0.80
6.	Chip chap	07.03.03	21.03.03	1.0	35.0	0.50	16.0	10.0	8.32	3.56	2.26	14.7.03	1.25	2.52	0.85
7.	Sewi	01.03.03	17.03.03	4.0	57.5	2.50	25.0	14.5	7.50	2.82	2.00	22.7.03	0.89	1.70	0.93
8.	Khuneizi	13.03.03	21.03.03	6.0	33.0	1.00	16.0	10.0	7.40	2.80	1.70	17.7.03	0.61	1.75	0.73
9-	Medjool	14.03.03	22.03.03	2.0	63.0	1.50	21.0	08.0	10.5	4.90	3.30	24.7.03	0.78	1.56	0.72
10.	Sabiah	17.02.03	12.03.03	2.0	70.0	2.25	35.0	14.0	8.60	3.03	1.90	22.7.03	0.60	1.70	0.83
11.	Dayari	15.03.03	22.03.03	9.0	85.6	1.75	23.3	07.0	9.25	4.10	2.30	22.7.03	1.14	2.46	0.86
12.	Muscat	17.2.03	28.02.03	6.0	72.6	1.00	34.0	14.0	7.30	3.23	1.57	08.7.03	0.75	1.73	0.80
13.	Tayer	14.03.03	24.03.03	3.0	44.0	0.50	27.5	11.0	7.00	2.93	1.80	14.7.03	0.80	1.78	0.78
14.	Umshok	17.03.03	28.03.03	3.0	46.0	2.00	35.0	14.0	6.10	3.10	2.10	17.7.03	0.76	1.76	0.83
15.	Hayani	12.03.03	19.03.03	3.0	28.0	0.50	22.0	06.5	7.50	3.00	1.67	17.7.03	0.56	1.98	0.78
16.	Hamara	25.02.03	05.03.03	5.0	50.0	0.50	19.0	05.0	7.42	3.20	1.80	16.7.03	0.79	1.88	0.62
17.	Sadami	20.03.03	01.04.03	3.0	70.0	1.50	31.5	10.0	7.00	3.00	1.60	13.7.03	1.10	1.93	0.76
18.	Medini	17.02.03	07.03.03	2.0	51.0	2.00	26.5	11.0	8.50	3.76	2.00	23.7.03	0.96	2.20	0.90
19.	Sayer	15.02.03	07.03.03	6.0	48.0	2.25	33.5	15.0	5.60	3.00	1.75	23.7.03	0.70	1.79	0.82
20.	Bikaner Local	04.03.03	15.03.03	3.0	55.0	3.00	28.0	20.3	6.40	2.83	2.10	17.7.30	0.86	1.76	0.83

Performance of Date palm Seedlings

Few seed of *Phoenix dactylifera* (EC 517310) was introduced from Tehran, Iran and seedling were raised in the nursery for field planting. Seedlings of Kachchh collections were planted in the field but survival rate was very poor.

Seedlings of date palm cultivars Sayar, Zahidi, Braim, Khastavi, Khadrawy, Chip chap and Barhee were transplanted in the field however, survival of plant was poor. For proper vegetative growth and flowering in seedlings, irrigation is required. On the boundary of date palm block, seedlings of date palm were transplanted at 2 × 4 m spacing with a view to assess plant growth, sex ratio, variability/ fruiting behaviour in seedling palms under arid environment. Survival and seedlings growth was poor due to drought situations.

Mulching studies in Date palm

An experiment was carried out to see the effect of mulching treatments on growth and fruit production in date palm. Two type of mulches viz. Black polythene and weeds +date palm pruned leaves were used with control (no mulching) in date palm cv. Halawy. Observations were recorded on palm height, spread, number of suckers/plant, spathe emergence, fruiting and berry characters. The preliminary results indicate that mulching improved the vegetative growth as well as berry characters in date palm under arid conditions.

A 1.4 Introduction, collection, characterization, conservation and evaluation of aonla (*Emblica officinalis* Gaertn.)

Germplasm status of aonla

At present 43 genotypes of aonla is being maintained in field repository.

Collection of bud wood of 9 aonla genotypes from Rajasthan and some varieties form Gujarat

An exploration was undertaken during July 2003 to collect bud wood of elite type aonla plants. Consequent upon exploration, bud wood of nine genotypes were collected out of that five plants were collected from Jaipur district (near Chomu) i.e. Nimri, Villpur and Morija and another four were collected from Ajmer district (near Pushkar valley) i.e. Basoli, Thawla and Raghunathpura etc and budded in-situ. Besides, bud wood of Anand aonla and Local selection series from GAU, Anand was also collection from Gujarat during August 2003 and budded in-situ at field repository of aonla

Floral biology of Aonla

Observation with respect to pollen viability, concentration of female and male flowers, flower

colour (male and female), number of female flowers/branchlet was recorded in seven cultivars of aonla i.e. Chakaiya, Krishna, Kanchan, NA-6, NA-7, NA10, Anand-1. Regarding pollen viability, an initial study was conducted and sufficient variation in pollen germination was recorded. The male flower was concentrated at lower side of determinate shoots whereas female flowers were located at middle to upper end. Regarding colour of female flower, it varied from light green to dark green with pink tinge but as far as colour of male flower is concerned it was cream to pinkish cream. The number of female flower/ branchlet was varied from 4-25 depending on cultivars.

Varietal evaluation of Aonla for growth, yield and fruit characters

During the year 2003-2004 profuse fruiting was observed in cv. NA7, NA-6, Chakaiya, Krishna Kanchan NA-10 and Anand-1. Based on observations recorded with respect to yield and yield attributing traits it was found that NA7 performed better over other commercial varieties under arid ecosystem. The maximum yield/plant was found in cultivar Narendra Aonla-7 i.e. 167kg with the average of 60kg Besides fruit weight was varied from 31-76.14g depending on cultivar highest fruit weight was recorded in Krishna i.e. 76.14g with the average of 48.3g followed by NA-6 NA-7 and Chakaiya and minimum was recorded in Kanchan.The average No of fruits/branchlet was varied from 3-12 depending upon variety (Table 5,6 & 7).

Table 5. Varietal evaluation of aonla cultivars on the basis of growth parameters

Cultivars	Length of determinate shoot (cm)	Leaf size (cm)	Internodal length of determinate shoots (cm)	Plant height (m)	Plan spread		Plan diameter (inch)
					EW(m)	NS(m)	
Chakaiya	9.10 (6-13)	1.6	0.35	2.50	3.00	3.00	32
Krishna	8.4 (5-12)	1.5	0.31	3.10	2.80	3.00	45
Kanchan	7.6 (5-11)	1.3	0.38	2.91	3.00	3.50	36
NA-6	16.6 (7-30)	1.8	0.81	3.21	3.25	4.00	50
NA-7	15.9 (6-28)	1.7	0.46	3.45	4.00	4.20	45
NA-10	12.3 (4-16)	1.3	0.42	3.11	3.20	3.20	42
Anand-1	10.5 (4-13)	1.4	0.38	2.10	2.75	3.10	33
SEM	1.143	0.208	0.396	0.132	0.614	0.154	06.617
CD at 5%	2.378	0.432	0.824	0.275	1.277	0.320	13.763

Note: Data given in parenthesis is range value

Table 6. Varietal evaluation of aonla cultivars on the basis of fruit characters.

Cultivars	Duration of fruit dormancy	Fruit size (cm)		Fruit weight (g)	Pulp weight (g)	Pulp content (%)	Stone weight (g)	Stone size (cm)		Seed weight (g)	Pulp/ stone ratio	Stone content (%)
		L	D					L	D			
Chakaiya	92	3.6	4.10	33.4	32.00	95.89	1.40	1.96	1.72	0.034	22.88	4.11
Krishna	95	3.7	4.60	48.3	45.96	95.15	2.34	2.45	1.92	0.036	19.65	4.85
Kanchan	99	3.6	3..95	31.25	29.69	95.01	1.56	1.82	1.68	0.031	19.03	4.99
NA-6	93	3.6	4.40	40.8	39.09	95.8	1.71	1.80	1.62	0.034	22.86	4.20
NA-7	91	3.5	4.00	36.52	34.93	95.64	1.59	2.01	2.15	0.028	21.98	4.36
NA-10	101	3.5	3.8	30.16	28.77	95.39	1.39	1.48	1.39	0.029	20.73	4.61
Anand-1	97	3.5	3.8	31.35	29.83	95.15	1.52	1.52	1.42	0.031	19.61	4.85
SEM+	2.970	0.470	0.512	2.094	2.544	0.282	0.234	0.278	0.249	0.0070	1.612	0.872
CD at 5%	6.179	0.979	1.065	4.356	5.291	0.588	0.488	0.578	0.518	0.0146	3.254	1.815

Table 7. Varietal evaluation of aonla cultivars on the basis of fruit quality parameters.

Cultivars	Juice content (%)	Dry matter (%)	TSS (%)	Acidity (%)	TSS/Acid ratio
Chakaiya	73.65	16.4	18.00	2.04	8.82
Krishna	75.30	18.39	17.50	2.35	7.65
Kanchan	69.36	14.75	14.90	2.70	5.51
NA-6	74.39	17.58	19.30	2.43	7.94
NA-7	75.38	16.8	15.20	2.51	6.05
NA-10	66.35	14.02	15.40	2.02	7.62
Anand-1	71.69	14.93	16.60	2.14	7.75
SEM+	03.594	02.109	02.139	0.275	1.052
CD at 5%	07.477	04.387	04.451	0.573	2.189

Germplasm evaluation for frost tolerance

12 genotypes were collected from Himachal Pradesh during 2002 and maintained in field repository of aonla. During February2004 there was occurance of frost. Observation with respect to frost damage/tolerance was recorded

Characterization of germplasm collected throught exploration

Characterization of 26 aonla germplasms collected through exploration from Gujarat (5), Himachal Pradesh (12) and Rajasthan (9) was done for vegetative characters such as plant height, girth, spread, leaf size etc (Table 8).

Fruit set studies in aonla

Initial study on Fruit set was conducted in 7 commercial varieties of aonla i.e. Chakaiya, NA-6, NA-7, Krishna, Kanchan, NA-10 and Anand-1. Based on observation maximum fruit set was found in cultivar NA-7 followed by NA-6, Chakaiya,Kanchan and NA-10 whereas fruit set was comperatively less in two cultivars i.e. Anand-1 and Krishna.

Effect of Calcium and Boron in relation to fruitfulness in aonla

Different concentrations (0.2%, 0.4%, 6%) and combinations (individually , mixed) of Calcium (as Calcium carbonate) and Boron (as Borax) was sprayed on aonla cultivars NA-6 and NA-7. Observation with respect to fruit set, yield and quality traits was recorded and it was found that mixed (Ca+B) application at the concentration of 0.4% gave promising results. Experiment is continued by incorporating leaf and soil sample analysis for Calcium and Boron contents.

Frost management studies in aonla

Different concentrations of H_2SO_4, NaCl and KNO_3 were applied through foliar spray. The incidence of frost was reported during 2003-2004 and data was recorded. The experiment will be repeated for conformity of the effect of treatments in forthcoming years.

A. 1.5 Introduction, evaluation and improvement of indigenous and exotic underutilized fruits of arid region.

The germplasm of under utilized fruits were maintained and evaluated for survival, plant growth, flowering and fruiting under hot arid conditions. During the year, survey and collections were made in U.P, Goa, Rajasthan, Gujarat for identification and collection of elite types. From rich variability, Jamun and karonda were also collected from Goa. A elite type wood apple was also collected from Udaipur to see the performance under arid conditions.

Table 8. Characterization of aonla germplasm for vegetative attributes collected through survey

S. No.	Acc. No	Year of collection	Area explored	No. of plants	Leaf colour	Plant height	Plant girth	Plant spread		Size of leaf (cm)	Size of determinate shoots (cm)
								EW (M)	NS (M)		
1	IC-322127	2000	Anand Gujarat	3	Dark green	2.75	16	2.5	3.3	1.5	23.3
2	IC-322128	2000	Sabarkatha	3	Dark green	2.5	15	2.2	2.3	1.5	22.5
3	IC-322129	2000	Sabarkatha	3	Dark green	2.5	18	3.0	3.1	1.2	25.2
4	IC-322130	2000	Sabarkatha	3	Dark green	1.5	04	1.5	1.5	1.1	21.7
5	IC-322131	2000	Sabarkatha	3	Green	2.2	04	1.6	2.0	1.2	18.9
6	AKS/CIAH /EO-6	2002	Shimla, H.P.	3	Dark green	2.3	07	3.2	1.5	1.1	24.9
7	AKS/CIAH /EO-7	2002	Shimla, H.P.	3	Dark green	3.4	11	1.3	2.2	1.5	28.3
8	AKS/CIAH /EO-8	2002	Shimla, H.P.	3	Dark green	1.2	15	2.3	1.2	1.8	24.3
9	AKS/CIAH /EO-9	2002	Shimla, H.P.	3	Dark green	2.2	10	3.1	2.5	1.1	24.1
10	AKS/CIAH /EO-10	2002	Shimla, H.P.	3	Dark green	2.5	15	3.3	3.2	1.4	29.2
11	AKS/CIAH /EO-11	2002	Shimla, H.P.	3	Green	3.4	18	2.5	3.5	1.3	27.6
12	AKS/CIAH /EO-12	2002	Solan, H.P.	3	Dark green	3.3	12	2.3	3.8	1.3	27.3
13	AKS/CIAH /EO-13	2002	Solan, H.P.	3	Dark green	2.4	18	3.1	2.3	1.2	23.2
14	AKS/CIAH /EO-14	2002	Solan, H.P.	3	Dark green	2.5	13.3	2.2	2.4	1.1	26.1
15	AKS/CIAH /EO-15	2002	Solan, H.P.	3	Light green	2.2	16.2	2.9	2.5	1.7	25.2
16	AKS/CIAH /EO-16	2002	Solan, H.P.	3	Dark green	2.9	17.3	2.5	3.2	1.3	23.3
17	AKS/CIAH /EO-17	2002	Solan, H.P.	3	Dark	3.0	14.9	3.2	2.2	1.4	26.1
18	AKS/CIAH /EO-18	2003	Jaipur Rajasthan	3	Light green	3.3	17.5	3.3	2.3	1.2	22.4
19	AKS/CIAH /EO-19	2003	Jaipur Rajasthan	3	Dark	2.2	16.2	1.4	3.2	1.1	23.7
20	AKS/CIAH /EO-20	2003	Jaipur Rajasthan	3	Dark	2.2	11.3	1.3	1.5	1.4	22.8
21	AKS/CIAH /EO-21	2003	Jaipur Rajasthan	3	Light	3.0	29.4	1.5	1.5	1.5	19.4
22	AKS/CIAH /EO-22	2003	Jaipur Rajasthan	3	Green	2.8	8.2	2.5	2.0	1.6	21.4
23	AKS/CIAH /EO-23	2003	Ajmer Rajasthan	3	Green	1.5	5.4	1.3	2.2	1.3	22.2
24	AKS/CIAH /EO-24	2003	Ajmer Rajasthan	3	Green	1.5	7.3	1.4	1.9	1.7	19.8
25	AKS/CIAH /EO-25	2003	Ajmer Rajasthan	3	Green	1.2	4.2	1.4	1.8	1.2	18.8
26	AKS/CIAH /EO-26	2003	Ajmer Rajasthan	3	Green	2.3	6.1	2.3	1.5	1.4	21.1

Karonda (*Carisa carandus*)

A seedling of karonda (green fruit type) was collected from Udaipur. A rich variability in karonda was observed in Mount Abu hills area which should be exploited. Four collections of karonda were also made from Goa and seedlings were raised in the nursery for further evaluation. For the development of repository, field preparation was done during the year. Six germplasms of karonda were transplanted in field in the month of February for evaluation. The survival of plant was better after two month of planting.

Phalsa (*Grewia subinaequalis*)

During the year, germplasm of phalsa was collected from Goa and S.K.Nagar. Plants were raised in the nursery for evaluation.

Four genotypes were evaluated for growth, flowering and fruiting under arid conditions. Out of four collections, flowering and fruit setting was started in all genotypes. Plants were pruned at 20 cm above ground level during winter season. These collections are of bushy type. During fruiting period, severe bird damage was observed in phalsa.

Lasora (*Cordia myxa*)

Sixty five collections were maintained under field conditions and evaluated for plant growth, flowering and fruiting. The growth performance was better in all genotypes. Further, 04 genotypes were started flowering at an age of three years. Under germplasm evaluation, two genotype were found frost tolerance type. Fruits were harvested at green stage. However, average fruit yield varied from 2 to 3 kg/tree during initial year of fruiting.

Ker (*Capparis decidua*)

Three saplings of each collection were planted in the germplasm block. However, the survival rate of plant was poor during the year.

Characterization of *khejri* for vegetable uses:

Six elite k*hejri* (*Prosopis cineraria*) genotypes producing quality pods (for fresh curries and pickles), were top worked for *ex situ* characterization and conservation. These genotypes were assessed for pod yield and quality components in response to crop regulation by pruning in the month of June to harvest both tender pods for vegetables and nutritive fodder (loong) in the twelve month cycle.

Cactus pear (*Opuntia ficus indica* (L.) Mill.)

During the year, a spineless type cactus was identified and collected from Mount Abu. The cladode of the genotype was planted in the pot for multiplication and evaluation.

Cactus pear genotypes were maintained for multiplication and evaluation for different purposes. Better plant growth was observed in clones 1269, 1270, 1271, 1280, 1281, 1378 and 1458 under multiplication in nursery. However, plants growth in other type was poor. Indigenous cactus types were started flowering and fruiting during winter season while flowering and fruiting in exotic genotypes was observed during summer season. Local indigenous types produced inferior quality fruits of small in size and sour sweet in taste. It has been observed that plants required proper soil moisture regime for growth and fruiting.

Vegetable type (1308) produced new cladodes i.e. nopalitos for green vegetable under assured irrigated conditions. The plant growth was better under shade condition in cactus pear type. Maximum fruiting was noted on the top of cladodes than that of other sides emerging cladodes and the number was 5-6 fruits per pad. However, better growth, flowering and fruiting was observed in clone 1270 and 1271 under arid environment. During the year, few fruits were formed in clone 1270 and 1271. However, other genotypes did not produced flowers and fruit.

The genotypes procured from Argentina were multiplied in the nursery for further planting and evaluation.

Introduction and evaluation of Exotic species

During the year, a fruit sample of Cactus pear (EC 527043) was introduced from Mexico through NBPGR, New Delhi in September 2003 and seeds were sown in the nursery but, seeds were not germinated. Cuttings of fig, tamarind were also introduced from Niger during January month but they could not sprout.

Exotic fruit species (Carob, Chinese jujube, Argan, Marula nut) were maintained in exotic species block. The highest survival percentage of plant was recorded in marula nut. Better plant growth was also recorded in Marula nut (*Sclerocarryo caffra*). Survival as well as vegetative growth in Carob (*Ceratonia siliqua*) and Argan (*Argania spinosa*) plant was poor. Effect of frost was minimum in Chinese jujube, Argan and Carob fruit species while Marula plant was highly susceptible to low temperature/frost. The plants of Chinese jujube started flowering and fruiting. Average size of Chinese jujube fruit was 2.40 × 1.76 cm. and weight 3.85g .The stone size was small.

A.1.6 Collection, conservation and evaluation of bael (*Aegle marmalos*) genotypes

Three plants of each genotype were maintained in repository during the year. Low temperature during winter season also affected the survival and growth of plants.

A survey was carried out in the Eastern districts of U.P. in collaboration with AICRP (AZF) centre, NDUAT, Faizabad to identify elite plant during the year 2003.Twenty four bael genotypes were marked. A rich genetic diversity was observed in Jaunpur district. A plant having age more than

100years, was identified and marked in Narayanpur village, Sultanpur district which was in good bearing (more than 200 nos. fruit). Fruit size, weight,flesh colour,TSS, Acidity and number of seeds per fruit were recorded from collected samples. On the basis of physico- chemical characters and fruits yield at farmers field ND/AH-3, ND/AH-5, ND/AH-8, ND/AH-9, ND/AH-10, ND/AH-12, ND/AH-13, ND/AH-14, ND/AH-15, ND/AH-16, ND/AH-17, ND/AH-18, ND/AH-19, ND/AH-20, ND/AH-21 and ND/AH-22 have been found suitable for further collection and quality evaluation. An elite plant with good bearing and free from leaf spot diseasse was also marked at Jobner. A seedling selection of bael was collected from Udaipur and S.K.Nagar and planted in the field for evaluation. Ninety per cent survival of plants was recorded but during establishment stage, plants growth was very slow. Further work on identification of better genotype and collection is in progress.

At CHES, Godhra

A 1.7 Collection, introduction and evaluation germplasm of some semi-arid fruits- Ber, Pomegranate, Aonla, Sapota and Custard apple.

Wood apple

In Wood apple germination per cent ranged from 15.56 to 62.40 and survival of the plants in the field was more than 80 per cent. Physico- chemical analysis revealed that fruit weight ranged from 187 g to 350 g, fruit length from 71.5 mm to 95.08 mm, fruit diameter from 69.84 to 86.00 mm, pulp weight per fruit from 83.23 to 155.69 g, skin weight from 82.93 to 164.49, T.S.S. from 10.67 to 14.33 and number of seed per fruit varied from 224 to 505.

Pomegranate

Observation on vegetative growth parameters revealed that maximum plant height and North-South spread was recorded in line-A (3.30m & 3.40m respectively). Whereas, highest stem diameter and East-West plant spread was in line-E (59.40 mm & 3.60 m, respectively).

Aonla

Clonal selections in Aonla evaluated for the forth year revealed that selection-6 was the best in respect of earliness and higher yield. Maximum number of branchlet with female flowers (110.67), number of fruit set(640), fruit retained (331) per shoot and percentage retention was recorded in the selection. Yield per plant was also highest in the selection (106.7 kg). The selection has been recommended for release.

Sapota

Varietal Performance studies in Seven Sapota cultivars revealed that plant height was maximum

(4.77 m) in Cricket ball. Whereas stock & scion diameter (26.83 & 23.33 cm, respectively) and plant spread N-S (7.03m) and E-W (7.07) was maximum in Kallipatti. Maximum number of flower cluster per shoot was recorded in Jumakhia (108.67) and minimum in Co-1 (48.33). Total number of fruit set per shoot was maximum in Jumakhia (216.33). Physico-chemical parameters of Sapota fruit indicated that fruit weight, length & diameter was maximum in Co-1 (120.33g, 62.57mm & 64.50mm respectively). Seed weight/fruit was maximum in Pillipatti though the fruit size was small. Highest TSS (29.00 °Brix) and Yield /plant (87.33 kg) was recorded in Kallipatti, proving it to be the best for commercial cultivation.

Custard apple

Custard apple cultivars showed that plant height and stem diameter was maximum in Island-gem (4.16m & 103.33mm, respectively). Plant spread (N-S & E-W) was maximum in Washington (5.60m and 5.30 m, respectively). Maximum Fruit & pulp weight was found in Island-gem (195.50, 99.25g,respectively). Seed weight/fruit and TSS was maximum in Local Sitaphal (15.75g, 30 °Brix, respectively). Highest fruit set and Yield per plant recorded in Atemoya x Balanagar (263.67, 26.84 kg, respectively). Actual leaf area was highly correlated with product of length and breadth. Regression analysis for all the varieties was also carried out to workout leaf area by non-destructive method.

A 1.8 Collection, introduction and evaluation of under exploited fruits- Tamarind, Jamun, Bael, Mahua and Chiraunji

Jamun

Thirty-three promising genotypes were selected and evaluated for their flowering, fruiting and fruit quality attributes. Length of panicle ranged from 10.50 cm to 18.00 cm and number of fruits per panicle 6.00 to 28.00 in different genotypes. Individual fruit weight ranged from 10.20 to 22.80g and pulp percentage 77.50 to 87.10. The TSS percent varied from 9.90 to 13.30, total sugar 7.50 to 9.54 percent and vitamin C content 35.50 to 48.00 mg/100g. On the basis of overall performance GJ-2, GJ-3, GJ-4, GJ-8, GJ-18 and GJ-21 were found to be promising.

Tamarind

Thirty promising genotypes were selected and evaluated for their flowering, fruiting and fruit quality attributes. Highest pod weight and length (26.00 g. and 17.00 cm respectively) were recoded in collection No.13. However, the maximum percentage of pulp was found in collection No.10 (54.13) followed by collection No. 18 and 20. TSS and total sugar were found to be highest in collection No.10. However, maximum acidity (14.20%) was found in collection No.14. On the basis of overall performance collection no. 10 and 13 were found to be promising.

Bael

Five varieties of Bael i.e. N.B-5, N.B-7, N.B -9, CISH Bael-1 & CISH Bael-2 were collected from NDUAT, Faizabad and CISH, Lucknow. All the varieties have been established in the field. Growth parameters will be recorded from July-2004.

Mahua

After making survey of the Panchmahals district and adjoining areas, thirty-five genotypes were selected & evaluated for flowering, fruiting and fruit quality attributes. Highest number of fruits per cluster (14.00) was found in collection No.2. Corolla (Mahua flowers) of collection No.5 had maximum weight (2.5 g) and Juice (68.00 per cent). TSS (26.00%) and total sugar (22.10) was also found to be highest in the same genotype. Ripening took place in the month of May and June in different genotypes. The weight of Mahua fruits varied from 12.50 to 40.00 g and seed weight from 5.67 to 22.50g. Kernel weight ranged from 4.20 to 16.00 g. TSS percent of fruits varied 12.00-16.30, total sugar 10.50-14.00 per cent and vitamin C content 42.00-63.50 mg/ 100g. On the basis of over all performance collection no 2, 5, 8,10 and 14 were found to be promising.

Chiraunji

After making survey of the Panchmahals district and adjoining areas, fifteen promising genotypes were selected and evaluated for their flowering, fruiting and fruit quality attributes. Maximum panicle length (41.50 cm) was recorded in collection No.1, however fruit set per panicle (38.00) was found to be highest in collection No.12. Maximum fruit weight and kernel weight was recorded in collection no. 1 i.e. 0.34 and 0.09 g respectively. Protein content was found be highest (30.50 %) in collection no. 2.

At CIAH, Bikaner

A 2. Introduction, collection, characterization, conservation and evaluation of vegetable crops under hot arid environment.

A 2.1 Introduction, collection, characterization, conservation and evaluation in cucurbit vegetables under hot arid environment

Realizing the importance of cucurbitaceous vegetables particularly the drought hardy species *Citrullus* and *Cucumis* in arid and semi arid regions of northwestern parts of India, research initiates were under taken since 1994 at CIAH, Bikaner. In this direction, a large number of landraces and semi-domesticated types of mateera / watermelon (*Citrullus lanatus*), roundmelon (*Praecitrullus fistulosus*), kachri (*Cucumis melo var. callosus/agrestis*), snapmelon (*Cucumis melo var. momordica*), muskmelon (*Cucumis melo*), kakdi (*Cucumis melo var. utilissimus / fluxuosus / acidulus*), bottlegourd (*Lagenaria*

siceraria) and Luffa gourds were collected over the years for systematic evaluation, characterization and conservation of indigenous germplasm of cucurbits. As a result of crop specific explorations in the arid and semi arid areas of Rajasthan and Gujarat and collections from target variability pockets and vegetable based institutions and NBPGR, over the years this institute is maintaining active collections of *mateera*, snapmelon, *kachri*, muskmelon, roundmelon (*tinda*), bottlegourd, ridgegourd and spongegourd. During the collection and preliminary evaluation of *mateera, kachri* and snapmelon germplasm (1997 to 99), the number of accessions were very high, therefore in 2002-03 data were analyzed for categorization of germplasm and limited number of accessions were developed for the maintenance and conservation. In kharif season 2003, mateera and snapmelon core samples were maintenance and evaluated, and freshly harvested seeds have been deposited in the National Gene Bank at NBPGR, New Delhi for long-term conservation. The current germplasm holding in vegetable crops at CIAH, Bikaner is as under (Table 9).

Variability in bottlegaurd from trible areas of Rajasthan and Gujarat

Table 9: Active germplasm in vegetable crops at CIAH

Crop	Accession	Crop	Accession	Crop	Accession
Mateera /watermelon	65	Bottlegourd	20	Chilli	45
Roundmelon	10	Ridgegourd	20	Brinjal	30
Muskmelon	60	Spongegourd	15	Cluster bean	05
Snapmelon	65	Bittergourd	04	Indian bean	30
Kachri	68	Pumpkin	04	Sword bean	01
Kakdi	18	Ivygourd	01	Other vegetables	35

Maintenance for the conservation of germplasm

a) Regeneration and conservation of *Mateera* (Rainy season 2003): As a result of explorations and collections (1994-96) followed by preliminary evaluation of *Citrullus* germplasm (1997 to 99), it was realized that the numbers of accessions were very high therefore in the year 2003 data were analyzed for categorization of *mateera* germplasm to develop limited number of accessions for the maintenance and conservation. Out of 193 base population samples, 36 core groups were formed and regenerated during rainy season at CIAH, Bikaner and characterized for phenological, growth, flowering and fruiting behaviour, fruit quality and yield components, seed characters, and also for biotic and abiotic stresses. The drought hardy Mateera AHW 1, 18, 19, 65, 82, 108, 118 and 140 were most potential for multiple uses. The bulk quantity seed material of 36 accessions has been deposited in National Gene Bank for long-term conservation at NBPGR, New Delhi.

b) Regeneration and conservation of Snapmelon (Rainy season 2003): As a result of intensive surveys and collections (1994-96) followed by preliminary evaluation of *Cucumis* spp. germplasm (1997 to 99), it was realized that the numbers of accessions were high, therefore, data were analyzed for categorization of snapmelon germplasm to develop limited number of accessions for the maintenance and conservation. Out of 90 base population samples, 37 core groups were formed and sown during rainy season at CIAH, Bikaner and characterized for phonological, growth, flowering and fruiting behaviour, fruit quality and yield components, seed characters, and also for biotic and abiotic stresses. The Snapmelon AHS 6,10, 14, 19, 50, 54, 64 and 82 were most potential. The sufficient quantity of multiplied seed material of 37 accessions has been deposited in National Gene Bank for long-term conservation at NBPGR, New Delhi.

Genetic improvement

Mission B: Genetic Improvement in arid and semi-arid horticultural crops.

At CIAH, Bikaner

B. 1 Improvement in Ber

Evaluation of back cross hybrid

The observations were recorded with respect to plant growth characters, fruit yield, fruit weight, stone weight, TSS and infestation of fruit fly etc.

Evaluation of H1, H2 and Sel. 1

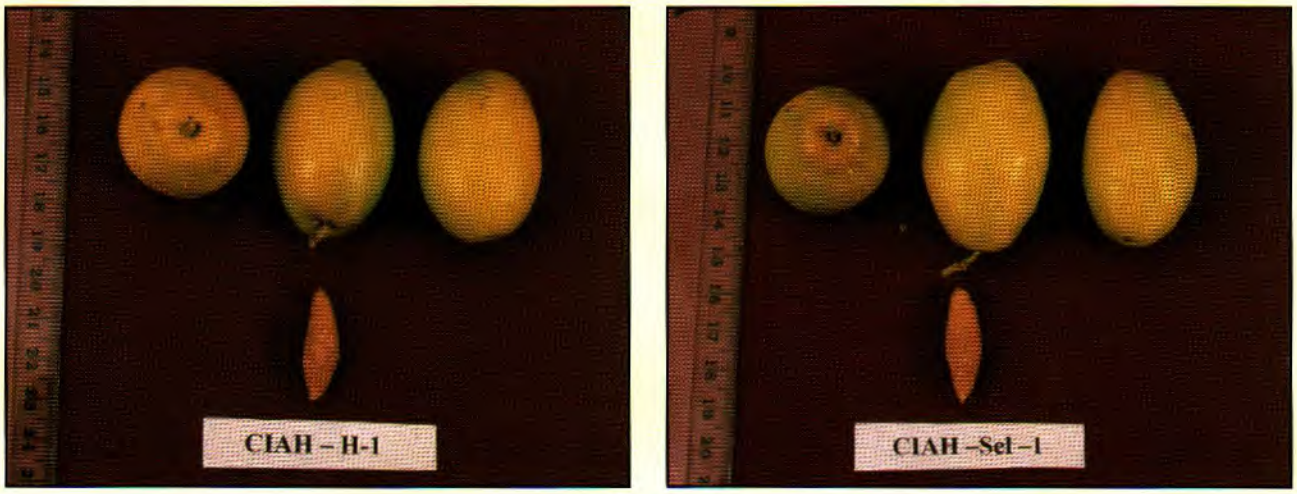
Observations with regards to plant growth characteristics, floral biology, fruit yield, average fruit weight, stone weight, dry matter content, TSS, Ascorbic acid content, total sugar etc. were recorded in CIAH H-1, CIAH H-2 and CIAH Sel-1 (Table 10).

Table 10. Important characteristics of Hybrid and Selection

Characters	CIAH Hybrid -1	CIAH Selection - 1
Plant height (m)	2.75	3.53
Plant spread (m)	4.9 x 5.10	4.85 x 4.56
Stem diameter (cm)	12.1	12
Length of thorn (cm)	0.57	0.60
Length of petiole (cm)	2.10	1.67
Thickness of petiole(cm)	0.20	0.17
Leaf size (cm)	8.3 x 4.6	8.37 x 4.3
Period of Bloom	30th August to 10th November	First week of September to First week of November
Peak time of Bloom	14th September to 30th October	15thSeptember to 30th October
Time of anthesis	10.30AM	7.30 to 8.30 AM and 12.30 PM
Number of flower/ cyme	26-28	24-28
Pedicel length (cm)	0.7	0.9
Time of fruit set	26th September to 2nd November	30thSeptember to 4th November
Peak time of fruit set	10th October to 30th October	14th October to 30th October
Maturity group	Early	Early
Fruit size (cm)	4.21x3.10	4.72x3.00
Fruit weight (g)	28	29
Stone weight (g)	1.25	1.29
Stone size (cm)	2.67 x 0.88	2.9 x 0.88
Dry matter content (%)	22	20
TSS (%)	24	22.00
Ascorbic acid mg/ 100g	89	62
Total Sugar (%)	5.10	4.50
Acidity (%)	0.53	0.49
Protein mg/g	16.10	13.20
Time of first Harvesting	First week of January	First week of January
Yield Kg/Tree	30-32	32-36

Observation with respect to self life of fruits of H1 and Sel. 1

An experiment was conducted to estimate the shelf life of CIAH Sel-1 and CIAH H-1 along with Gola (check). Fully matured green fruits were harvested and kept in different material ie. polythene bag, paper bag, gunny bag, corrugated fibreboard boxes and in open condition under room temperature during January. Observations were recorded on physiological loss in weight, number of days taken for colour change from green to yellow to red and pathological infection. It was observed that CIAH H-1 and CIAH Sel-1 can be kept in room condition for four five days after harvest.



Promising germplasm of *ber*

B.2 Improvement in pomegranate by selection and hybridization

Evaluation of F_1, F_2 and self and open pollinated progenies:

The objectives of pomegranate breeding under extremes of arid environment is to evolved an ideal genotype having big sized fruits with appealing outer rind and dark red, bold, soft and sweet aril and also consistence fruit quality for longer period of harvesting. On the basis of regular evaluation of the developed F_1, F_2 and self and open pollinated progenies over the years at CIAH, Bikaner, now it was clear that there is an urgent need to identify genotypes or individuals from the developed progenies devoid of fruit cracking and could provide better marketable fruit yields under arid conditions. Out of 15 F_1 hybrids, the F_1 progeny (DKS/H/97/003) produced better quality fruits, while 12 progenies produced sour type fruits. Among open pollinated seedling progenies of Jalore Seedless, the fruits of progeny (AHP/OP/JS/98/10/45) were superior to cv. Jalore Seedless. Whereas the fruits of open pollinated progenies developed from Iranian type were sour. The important fruit quality characteristics of promising plants of desirable progenies were critically observed through out the fruiting period. Among soft and sweet type F_1 progeny DKS/H/97/003, plant number 3, 16, 21, 17 and 22 and open pollinated progeny AHP/OP/JS/98/10 plant number 45 have been found promising for large scale testing. The heavy bearing sour and blood red colour aril producing plant number 9 of F_1 progeny

DKS/H/97/001 has been found to be promising for preparations of *anardana.* On the basis of in depth assessment and critical analysis over the years, some suggestive guidelines have been generated, these includes -

- On the basis of the analysis of component of variability, it is evident that number of fruits per plant, fruit yield per plant, fruit weight and weight of 100 arils deserves due weightage while formulating selection strategies for improvement in pomegranate. Thus, selection of superior types based on fruit yield components would be effective after ensuring the acceptable fruit quality components in the breeding material.

- Introduction of pomegranate cultivars from mild temperature regions (Iran, Iraq, Russia, Afghanistan) for direct exploitation as a commercial variety in arid and semi arid regions of India would be completely failure because they behave like deciduous.

- Seed hardiness is a varietal character and attempts must be made to breed varieties with softer seeds. Seed hardiness is a dominant character.

- Fruit cracking is a serious problem under extreme of arid environment. Studies reveal that all the commercial varieties/progenies depicted severe fruit cracking (50-80 %) as a *Mrig bahar* crop. High temperature conditions (>38 ^{0}C from March to October) limits the period of crop harvesting under hot arid condition with the manipulation in crop regulations and badly affected the aril colour, softness and quality of fruits. The pigment anthocyanin content is generally of lower order in fruits harvested between April to August in comparison of higher level in the fruits harvested in between November to January.

B. 3 Improvement in vegetables crops under hot arid environment

Realizing the potentialities of vegetable based production systems in the hot arid and semi arid regions, systematic vegetable improvement work was started since 1994 at CIAH, Bikaner by collecting land races, local cultivars and varieties of potential crops. During the first five years (1994 to 1999) the major emphasis was on two important cucurbitaceous genera i. e. *Citrullus* and *Cucumis* and later on chilli was incorporated in 1998. Mean while, some most popular and potential crops were also added like gourd vegetables and arid vegetable legumes in the improvement programme considering the requirement of superior genotypes for the cultivation under the extremes of climatic conditions. As a result of characterization of large number of germplasm accessions in potential vegetable crops followed by systematic selection and hybridization work over the period at the institute, some advanced lines in potential crops were generated, of which some were evaluated during spring - summer and/or rainy winter season of 2003 04 at CIAH farm for the advancement of generation and/or performance studies over the seasons/years.

***Mateera* (watermelon)**

Evaluation of advanced progeny blocks for high quality in *mateera* (Summer 2003): In continuation to the results of work done in drought hardy *mateera* landraces and thereafter hybridization to improve drought hardy *mateera* selections for higher TSS and quality marketable fruit yields *at par* with standard watermelon under hot arid conditions, during summer 2003, four advanced progeny blocks ($F_{6/a}$ - AHW 19 × Sugar baby) and one *mateera* variety (AHW 65) were evaluated as a large scale varietal trial. The characters related to earliness, fruit yield and quality, reaction to flowering and fruiting behaviour and fruit cracking under extremes of high temperature (> 40 ^{0}C) were recorded to screen the developed material (Table 11).

In comparison to mateera variety, all the four progeny blocks (F_6/a/3, F_6/a/7, F_6/a/9 and F_6/a/10) depicted consistent trends in growth, earliness, and fruit yield, number of fruits/plant and fruit size, shape and flesh characters (Table-11). The fruits of advanced progeny F_6/a/10 and F_6/a/7 block were externally much similar and highly acceptable in quality depicting internally as good as sugar bay and outer as *mateera*.

Table 11. Average performance of drought hardy watermelon and mateera (Three seasons)

Characters	F6/a Drought hardy watermelon	Mateera AHW 65
Days to male flower (DAS)	35.20	34.50
Node to male flower	08.50	09.50
Days to female flower (DAS)	42.50	40.20
Node to female flower	16.20	14.80
Days to first harvest (DAS)	78.50	74.40
Number of marketable fruits/plant	03.29	04.47
Fruit weight (kg)	03.54	02.75
Fruit yield/plant (kg)	11.50	11.70
TSS (^{0}Brix)	11.20	08.20
Edible flesh colour	Red	Dark pink

Rainy 2003: On the basis of the highest fruit quality and early yields in four progeny blocks (F_6/a/3, F_6/a/7, F_6/a/9 & F_6/a/10), the same seed material was used for testing as a rainy season crop. Observations on growth, flowering and fruiting behaviour, earliness, fruit yield and quality-contributing traits were recorded and analyzed (Table 12). The advanced progeny block (F_6/a/10) of *Mateera* AHW 19 x Sugar Baby depicted desirable fruit quality characters and high yielding as a rainy season crop.

Table 12. Performance of advanced progenies of drought hardy mateera (watermelon)

Season	Summer season 2003				Rainy season 2003			
Progeny block	F6/a/3	F6/a/7	F6/a/9	F6/a/10	F6/a/3	F6/a/7	F6/a/9	F6/a/10
Days to first harvest (DAS)	78.5	74.3	80.2	74.5	76.2	74.2	73.5	72.5
Marketable fruits/plant	03.1	03.8	03.2	04.0	03.1	03.3	03..2	04.1
Fruit weight (kg)	03.9	03.8	03.9	04.2	02.9	02.9	02.9	02.9
TSS (^{0} Brix)	10.1	10.4	11.2	11.2	10.2	10.4	11.0	11.1

Kachri

Yield performance of *kachri* : *Kachri* AHK119 was tested in summer season of 2003 using open pollinated seeds from selected plants of first and second harvest separately to assess the earliness and yield potential and also stability over the season under variable weather conditions of arid agro-climate. Besides, to improve the productivity some treatments were also imposed i.e. channel to channel and plant to plant spacing which were deviated from the recommended and bio-regulators (GA3 and thio-urea).. Observation on growth, earliness, days to first harvest, number of fruits/plant and total yield was recorded. On analysis of data, it was observed on an average the *kachri* AHK119 accounted yield potential of 93.5 q/ha under normal production system. In comparison to recommended technology, the imposed treatments depicted variable trends and that was not excelled ± 4.2 q/ha.

Snapmelon

Yield performance of snapmelon varieties : Snapmelon varieties recommended by CIAH *i.e.* AHS 10 and AHS 82 were tested during summer and rainy season 2003 respectively adopting normal packages of production to assess the yield potential and stability over the years under varying agro-climatic conditions. On an average under normal management practices, the variety AHS 10 bears 4.75 fruits/plant during summer with an average yield potential of 225 q/ha. The variety AHS 82 recorded average yield potential of 238 q/ha in rainy season with 5.75 fruits/plant.

Improvement for quality yields adopting management of production site approach: The restrictions imposed by nature in the north western parts of Indian arid zone such as: extremes of temperatures (high and low); low and erratic rainfall; high aridity, evapo-transpiration, solar radiation and wind velocity with dust storm; poor soil fertility coupled with low water holding capacity, poor quality limited irrigation water hampered full potentiality of crop genotypes, thus the productivity of vegetables is low. However, the yield potential a given genotype is fully exploited only when a favourable environment is provided. The environment in this context of crop management under arid regions refers to planting time, methods, spacing, use of bio-regulators and management of soil media, water and nutrient and microclimate of production sites.

Snapmelon is one of the popular rainfed vegetables during rainy season and now gaining importance as irrigated summer crop. The cultivars AHS 10 and AHS 82 developed and recommended by the CIAH are first priority among the growers owing to uniform higher early yields of better fruit quality. A series of experiments are continuing to standardized advance and innovative production technologies for stressed environment for the maximization of quality fruit yields with better utilization of resources. During the rainy season of 2003, four types of experiments on snapmelon AHS 82 crop, viz., i) method and spacing of crop planting, ii) Soil and moisture conservation practices, iii) water management and iv) use of bio-regulators were imposed and assessed for maturity, fruit set, yield and quality parameters. In general, under recommended open furrow (channels) system of crop production, spacing of 0.60 + 1.90 × 0.50 m was found to be the optimum for higher fruit yield per unit area. The summary of various experimental treatment combinations depicted higher yields of about 25-30 % with drip (single line, 2.5 × 0.50 m), 15-20 % in mini-sprinkler (5.0 × 2.0 m, six plant/MS), 25-30 % with dry hay mulch and 20 - 30 % with foliar application of GA3 20 ppm and revealed promise for better resource utilization for higher gains in snapmelon under arid conditions.

The variety AHS 82 recorded yield potential of 231 q/ha (5.65 fruits/plant) under normal recommended production practices in *kharif* season. The moisture conservation practices *i.e.* organic hay mulch using locally available weeds/grasses (*bui, khimp* and *sewen*) in channel and near by ridges towards vine spread areas (1.2 m), significantly improved the number of marketable fruits and fruit yield/plant (Fig. 3). The increased fruit yield/plant (7.14 kg) was 41 percent under moisture conservation practices over the control (5.05 kg). Among the bio-regulating substances, highly encouraging and significant results were obtained for growth; flowering and fruit set and fruit yield components. The highest fruit yield (7.75 kg) per plant was obtained with the application of GA_3 20 ppm followed by foliar application of thio-urea and urea (7.23 and 7.05 kg) in comparison to control (5.05 kg).

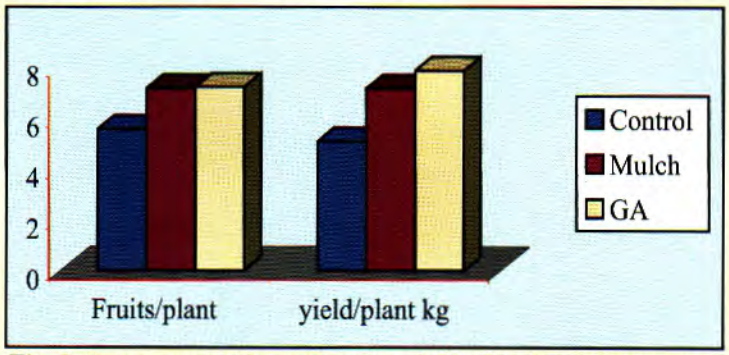


Fig. 3. Improvement in snapmelon yield adopting management of production site approach

Salad kakdi

Advanced progeny of *salad kakdi* variety AHC 2 was evaluated for fruit shape (straightness), earliness and yield potential during summer 2003 and selected potential plants were selfed for further evaluation. Data for maturity and fruiting behaviour under extremes of high temperature and yield contributing characters were recorded (Table 13) in both the *salad kakdi* (non-dessert forms of *Cucumis*

melo) varieties AHC 2 and AHC 13 for stability analysis over the seasons and years under varying agro-climate.

Table 13. Performance of Salad kakdi (non-dessert forms of *Cucumis melo*)

Characters	AHC 2 (Long fruited)	AHC 13 (Small fruited)
Days to male flower (DAS)	35.8	35.4
Days to female flower (DAS)	46.2	37.5
Days to first harvest (DAS)	56.5	45.3
Number of marketable fruits/plant	11.5	22.5
Fruit weight (kg)	270	078
Fruit yield/plant (kg)	3.11	1.75
Number of branches/plant	06.2	07.2
Vine length (m)	02.5	1.97

Bottle gourd

Bottlegourd (*Lagenaria siceraria*) is a popular and commonly available vegetable crop in the country. The yield potential of bottlegourd is very low in the arid region owing to non-availability of better genotypes for the cultivation under high aridity and temperature conditions. On the basis of results of research trials conducted in arid and semi arid regions of Rajasthan, its fruits could be made available from March December, with the modification in the sowing time and production technology. The work on bottlegourd breeding was started as early as in 1995 at Bikaner by evaluating more than 75 genotypes comprised of landraces, local cultivars, varieties/hybrids and advanced parenal lines and their F_1 and F_2 derivates in a phase manner. Subsequently potential lines were identified and further advanced for the purification. The potential lines were continuously tested over the seasons and selections were made for earliness, higher fruits set, yield and quality components under the arid situations for the commercialization of bottlegourd.

Bottlegourd AHLS Round 1: Among the round-fruited type, AHLS Round 1 (derived form the segregating F_2 population of cross combination Banswara local 1 × Gujarat Local-1) has been stabilized for uniform fruit yield and the earliest harvest (Table 14). The attractive ovate-round fruits of about 450-750 g weight are excelled for organoleptic vegetable quality. Fruits of the above size ('A' grade) are ready for marketing within 8-10 day from fruit setting. The first marketable picking starts from 50-55 days of crop sowing.

Bottlegourd AHLS Round-1 developed for cultivation under arid conditions

Table 14. Performance of bottlegourd AHLS Round 1 (Average of two years)

Characters	Spring-summer season	Rainy-winter season
Days to male flower (DAS)	42.2	38.7
Days to female flower (DAS)	50.5	47.1
Days to marketable harvest (DAS)	57.8	52.5
Number of marketable fruits/plant	05.54	08.9
Marketable fruit yield/plant (kg)	03.82	05.82
Number of branches/plant	06.1	06.1
Vine length (m)	02.54	02.45

Round melon

Roundmelon (*Praecitrullus fistulosus* Pang.), commonly called as *tinda* is an important summer and rainy season crop in arid and semi arid areas of northwestern Rajasthan. Its immature fruits are used in *rayata* or vegetable curries. This short duration crop is becoming very popular in north India due to its high nutritive value, taste and keeping quality and high remunerative prices. It may be an excellent export cucurbitaceous vegetable from the arid region. With the modifications in production technology, its fruits could be made available for as long as eight-month *i.e.* March to October. At present, the yield potential of roundmelon is very low compared to other cooking type cucurbits grown in the arid region. This is due to non-availability of seeds of standard genotypes producing better quality fruits under the prevailing climatic conditions of arid region. The results on cucurbitaceous crop evaluation over the years at CIAH, Bikaner revealed that, the unfavorable environmental conditions of arid regions hampered to expresses full potential of the genotypes those are from the favourable areas and this is more in roundmelon under extremes of high day time temperature for longer period (>40 ^{0}C),

high soil surface temperature (>55 ^{0}C) in the noon time and continuous high wind (*andhi*) and hot winds (*loo*) during the summers.

The collection and evaluation of roundmelon germplasm was started as early as in 1995 at CIAH, Bikaner. As a result of continuous collection of roundmelon landraces available in the *Thar* desert, landraces or open pollinated local cultivars grown in semi arid areas of Rajasthan and four standard varieties over the period, up to 2002, 31 landraces / genotypes were characterized for vegetative growth, maturity, fruit yield and quality characters and wide range of variations were recorded. Some potential types were identified from the landraces and purified over the period and tested for earliness, fruit quality and fruit yield potential under extremes of high temperatures conditions.

Roundmelon AHRM 1: This is developed by recurrent selection from the local landraces grown during rainy season in the arid region. It is early in maturing and for uniform high quality fruit yield. The tender fruits of 80-120 g weight are ready for first harvesting in between 45-50 days after sowing. About 15-18 tender fruits can be harvest giving average yield of 1.25-1.98 kg per vine under arid conditions. On the basis of encouraging results for improving quality fruit yield per unit area in cucurbitaceous vegetable, by use of dry hay mulching, GA_3, thio-urea and urea under arid conditions, similarly a large-scale experimental trial was conducted on round melon during summer season of 2003. Experimental results revealed positive trends for higher marketable fruit yield of about 20-30 % with the application of dry hay mulching in vine-spread area, foliar spray of GA_3 (20 ppm) at 2-4 true leaf stage and light sprays of urea (2 %) at 25 and 40 days of crop growth in comparison to normal crop production practices in roundmelon genotype AHRM 1.

Chillies

The main objective of improvement in chilli is to recognize the original *Mathania* type (popular landrace), which is at present completely a mixture for cultivation, low yielding and lost its quality attributes for which it was popular in north-western parts of Rajasthan. Two phenotypically uniform progeny block developed on the basis of fruit quality component characters of previous year crop were evaluated during rainy-winter season *i.e.* August 2003 to January 2004. Detailed observations on plant growth, flowering, days to first harvest (green and red ripe fruits), number of fruits and fruit yield /plant and fruit quality components were recorded to assess the potentiality. In general, fruits of most of the plants within the progeny block were more or less uniform. When fruit of both the progenies (green/ red ripe stages) were collected in a single lot, they resembles to *Mathania* type.

Brinjal

Brinjal (*Solanum melongena* L.) is the most popular indigenous vegetable and has regional consumer's preferences. In arid and semi arid regions of the northwestern parts of India, in particular to

Rajasthan and Gujarat, it is an important rainy-autumn season crop, and also to some extent as ratton and summer crop. The fruit yield potential is very low and wide variations do exist in the form of size, shape, colour and quality of fruits and maturity and fruit yield in the land races or local types being grown in the regions. The main reasons might be due to consumer's preferences for the specific types of brinjal in the different localities/ communities and different level of selection pressure for the maintenance of desirable landraces/local types in this indigenous crop by the growers and tribal community There is increasing demand of its varieties for different culinary purposes, besides better quality and high yielding genotypes for the cultivation under the extremes of high and low temperature conditions in the arid region. There is glaring need for the genotypes with in built tolerance mechanism to abiotic (drought and low temperature) and biotic (fruit borer infestation) stresses and earliness to fruit picking (<50 DAT) in brinjal.

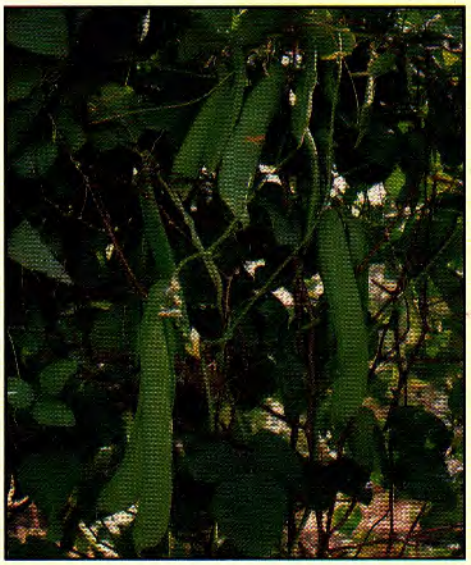
In spite of commercial significance of brinjal cultivation in the hot arid regions of northwestern parts of India, no much attention has been paid towards the development of superior genotypes for environmentally stressed areas. The work on brinjal improvement at CIAH, Bikaner was started from 2000 by evaluating more than 100 genotypes, which consisted of land races/local types (25), standard varieties/hybrids (10), parental lines (10) and 45 F_1 and some F_2 progenies in a phase manner. All the brinjal genotypes were characterized and categorized for important economic characters with a view to develop further strategies for the crop improvement. On evaluation, genotypes depicted wide range of variations for plant growth, flowering and fruiting behaviour, maturity, and fruit yield and quality traits. The genotypes were also screened for the tolerance to fruit borer infestation and high and low temperature effects to assess the suitability of the genotypes for the commercial viability. The synthesis of experimental results revealed that there is an urgent need for brinjal genotypes possessing in built mechanism for tolerance towards fruit borer, better fruit set under high/low temperatures, earliness (<50 DAT). Among the evaluated genotypes, good number of landraces, varieties, F_1 and F_2 derivates were high yielding with better fruit quality but lacking in one or two above described and important requirement, which are urgently requested by the arid zone brinjal growers.

Keeping all the facts in view, two lines were further advanced and evaluated during *kharif* season of 2003-2004. The genotype AHB-2 (F_3), developed through recurrent selection from the local material of Jalore district, took about 50 days for first marketable picking and the yield potential is 5.84 kg/plant. The average fruit weight is 100 g. This genotype still required further purification for uniform and higher early yield. The very potential advanced progeny (F_3) of AHB 04 × PPC depicted enough variations for earliness, clustering behaviour, fruit size and quality, spiny and plant growth characters and tolerance to fruit borer infestation and fruit setting under high temperature. Desirable plants were marked and selfed for generation advancement. To advance the generation, selection was made for the medium sized, non-spine plants producing non-spiny fruits of high quality. These plants were early to first harvesting, cluster bearing and high yielding with least fruit borer infestation (< 5 %). The progeny mean for first fruit picking was 45 days from transplanting. The number of fruits per plant was varied from 45-110. The oblong-round shaped fruits of 50- 85 g were excellent for marketing.

Sword bean

Sword bean (*Canavalia gladiata*) is an under exploited leguminous and its green tender pods are used for vegetable purposes. During the various explorations undertaken for the surveys and collections of arid horticultural crop germplasm from parts of Rajasthan and Gujarat under NATP on sustainable management of plant bio-diversity, interestingly on discussions with the tribal peoples it was emerged out that the sword bean is in cultivation for generations. However, it was restricted to the sub-human agro climate and few tribal families cultivating it for domestic consumption and to earn some contingencies by selling its tender pods in the domestic markets. This encourages for collection of germplasm and characterization of the collected material with the hope to identify promising types for the successful cultivation under the arid agro-climatic conditions.

Sword bean AHSB - 1 (INGR 04056): Developed by recurrent selection from the collected local germplasm grown in tribal areas of south Rajasthan and northern Gujarat. This drought tolerating genotype is very early for harvesting under extremes of arid conditions of northwestern India and produces uniform pods for vegetable use at tender stages. Light green colour immature pods of about 20-25 cm length, 3.0-3.5 cm width and 50-60 g weight are excellent for organoleptic quality of vegetable curries. Climbing type plants are medium in growth habit with dark green leaf and white colour flowers. Flowering starts in 68-72 days, where first picking is from 95-100 days of sowing as a rainy season crop. The final pod retention is varied from 2 to 5 per spike there by yield of marketable tender pods per plant ranged between 1.2 to 1.5 kg/season.



Sword bean AHSB-1 developed for hot arid conditions

Indian bean

Dolichos bean (*Lablab purpureus* (L) Sweet) also known as Indian bean or *sem*, is primarily grown for green pods which are cooked as vegetable like other beans. The dry bean seeds are also

collected for various vegetables preparations. The Indian bean is relatively winter season crop for cultivation under mild agro-climatic conditions. It is an annual but the plants can be retained for two to three years. The cultivated forms producing good quality pods are vine type and require proper support. As a result of good number of collections in Indian bean landraces from tribal dominating semi arid to sub humid areas of south Rajasthan and northern-central Gujarat under NATP on plant bio-diversity, the material was simultaneously characterized over the years under hot arid conditions. The landraces exhibited a wide genetic variations for growth, maturity, flowering and fruiting behaviour, pod quality and yield contributing traits under extremer of hot arid environment and depicted promise for the selection of better genotype directly from the population for further evaluation and purification to identify genotype for commercial cultivation and crop diversification. As a result of recurrent selection in promising genotypes, encouraging results were obtained (Table 15) to identify the early harvesting types (as early as in mid October) and high yielding for commercial cultivation (AHDB 16, AHDB 3 and KSB 66/a) under arid conditions.

Table 15. Performance of advanced lines of Indian bean (Rainy winter season)

Characters	AHDB 3	AHDB 16	KSB 48/a	KSB 49/a	KSB 66/a
Days to 50 % flower (DAS)	080.2	70.5	085.5	090.2	075.5
Days to marketable harvest (DAS)	105.8	95.2	114.5	113.5	105.4
Pod length (cm)	013.5	09.2	009.8	014.1	012.8
Pod weight (g)	008.45	06.85	005.47	008.45	007.64
Pod yield/plant (g)	00850	980	560	975	730

Indian bean AHSB-3 high yielding genotype developed for hot arid region

Cluster bean

The cluster bean (*Cyamopsis tetragonoloba*) grown as rainfed crop during monsoon in northwestern India in large average is for guar grains and gum industry. The tender pod of grain type

cluster bean is used extensively as a vegetable even after poor quality and is most common poor man's vegetable crop in the arid areas of western Rajasthan. Although, there are some good genotypes possessing better vegetable purpose quality and these vegetable type genotypes are mostly grown as summer season crop with assured irrigations. The vegetable type genotypes are not suitable for the cultivation under rainfed conditions of western Rajasthan because of scanty, uneven and uncertain rains (150 300 mm) during the crop period (July to September) and extremes of high temperature and aridity conditions. The performance of the standard vegetable type genotypes under rainfed condition is very poor and therefore, there is no alternate cluster bean variety possessing vegetable type quality for the cultivation under rainfed condition in arid areas. Thus, under these situations the desert dwellers are using pods of grain types for vegetable even knowing its poor organoleptic quality characters. A good number of genotypes possessing vegetable quality characters in pods are available but required mild agro climate or better and uniform rainfall distribution (350-400 mm) at least in 9 to 12 rainy days with ideal spells during the crop growth period or alternate sources for the irrigations during long dry spells. Keeping all the above facts in views, the work was taken up as early as in 1997 with a clear objective for high quality vegetable type cluster bean for the cultivation under rainfed situations in arid areas of western Rajasthan.

Vegetable type Cluster bean AHG 13: Developed through recurrent selection having single stem plant type from vegetable type cluster bean germplasm collected from Churu districts of Rajasthan. This selection is for thin and medium long pods of high quality for vegetable purposes and cultivation under rainfed condition of arid eco-system (<250 mm) and has also better response towards the favorable situations for higher yields. The plants can attain a height of 75-145 cm under verging conditions. The number of clusters per plant and number of pods per cluster varied between 9-21 and 7-15, respectively. Bearing starts from the plant base at 2-3 node position. The light green colour tender pods at marketable stages are 6.5 8.5 cm in length and 0.38-0.45 cm in width. The pod has 0.3-0.5 cm long string. Average pod weight at tender stage is 0.917 g and 1.85 g at fully grown green stage. The number of branches per plant in initial population was 2-3 or slightly branching type, and therefore continuous selections were made for the single stem type and after F_7 generation about 60 percent plant were of single stem and remaining with one additional but productive side branch. Average internodal length in plant is 6.4 cm. This selection is suitable for sowing both in spring-summer and rainy season crop and first picking starts from 50-55 days after sowing.

An innovative technology for production of vegetable type cluster bean (AHC 13) under rainfed situations in the extremes of arid environment has been standardized for commercialization. Some of the important steps involved in this innovative technology "Management of Production Site Approach" includes: -

I) Development of production sites to create favourable environment for the rainfed crop cultivation,

II) Preparation and maintenance of production sites for *in situ* rainwater harvesting, and regular soil moisture conservation,

III) Seed selection and treatment, sowing time and techniques, maintenance of plant population and crop protection from wild animals, rats, etc.

IV) Regular harvesting of the tender pods; grading and marketing; on farm value addition technology for dehydration of tender pods, and

V) Seed production technology for the maintenance of genotype and quality seeds.

Seed spices

Performance of minor seed spice genotypes under hot arid conditions:

The seed spices are aromatic vegetable product used in whole or ground form for imparting flavour and pungency to food. In India, *ajowan* (*Trachyspermum ammi* L.) and ***sowa*** (Indian & European dill, *Anethum sova* & *A. graveolens*) are minor seed spice crops and has tremendous potential for the crop diversification in arid and semi arid parts of the country. *Ajowan* is aromatic and herb spice, mostly dried fruits are used as spices. *Sowa* is aromatic and herbs spice mostly dried fruits and leaves are used. In Rajasthan, *ajowan* and *sowa* are commonly grown in the districts of Chittorgarh, Udaipur, Jhalawar, Kota and Bundi and near by districts with sub humid agro-climate.

The yield potential of minor seed spice is low primarily due to non availability of seeds of better genotype for the cultivation under the prevailing agro climatic conditions of the state and secondly because of poor management of production sites even after the low input requirements. Owing to drier conditions, the arid regions of northwestern parts of Rajasthan offer an excellent opportunity for high quality seed spices or organically seed spice production and, therefore, the high-valued and short duration seed spices crops could be the best alternative under limited inputs (like irrigation water). In this part of arid region, *ajowan* and *sowa* are not yet popular and therefore, needs introduction and large-scale varietal trials. Recently two high yielding genotypes of *ajowan* (AA 19 and AA 61) and three of *sowa* (AD 6, AD 32 and AD 43) have been identified by NRC on seed spices, Ajmer and recommended for large-scale varietal performance trials under varying agro-climatic conditions of the state. Therefore these were tested as a winter season crop (October 2003 to April, 2004) at CIAH, Bikaner and results are summarized and demonstrated (Fig. 4).

In *ajowan*, both the varieties were *at par* for maturity (±150 days) and the genotype AA 61 and AA 19 recorded seed yield potential of 3.66 and 4.97 q/ha, respectively. The *sowa* genotype, AD 6 and AD 32 were medium in plant height (105-110 cm) and early to maturity (±140 days). The plants of variety AD 43 were tall (160 cm) and prone to lodgeing and took 150 days for maturity. All the three genotypes of *sowa* depicted wide variations for number of umbles/plant (17.8-30.1) and seed yield potential (4.75-16.4 q/ha) under hyper arid agro-climate of western Rajasthan.

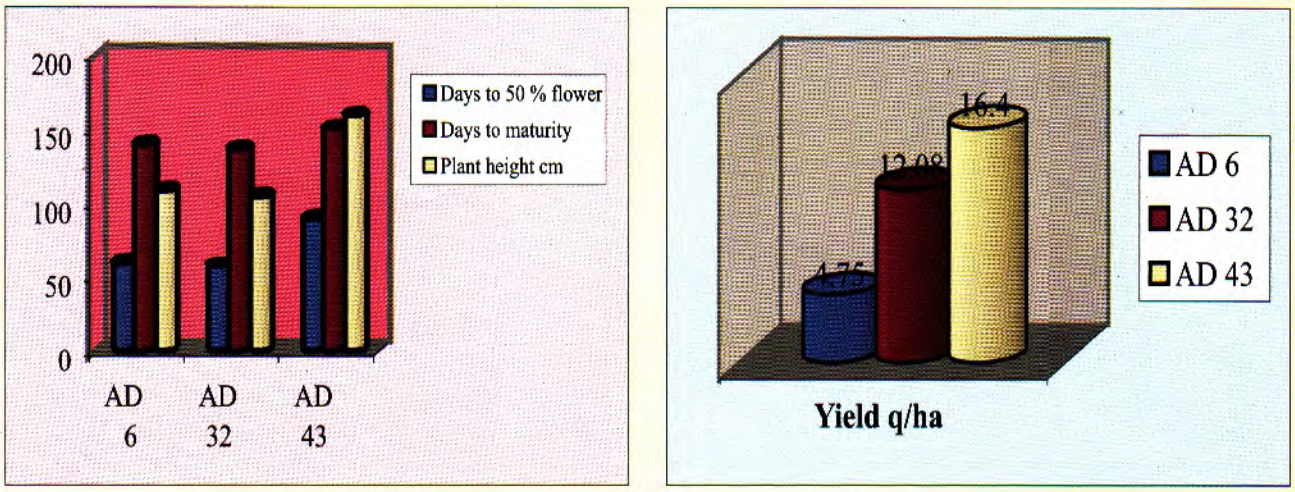


Fig. 4. Performance of Dill (Sowa) Varieties

At CHES, Godhra

B-4 Breeding for yield, quality and biotic and drought resistance in cucurbitaceous crops.

Pumpkin

Forty five pumpkin germplasms were evaluated in the rainy season and 57 in summer season for the yield and quality. The genotypes exhibited significant differences for all characters. The first female flower was observed in CM-14 (rainy season), CM-20 (summer season). Node at which the first female flower appeared in CM-17 (rainy season) and CM-20 (summer season). The highest number of female flower per plant were observed in 10.24 (CM-16) in both the seasons. The maximum of 6.36 fruits/plant were harvested in CM-16 (rainy) and CM-20 (summer season.). The highest yield per plant (15.38 kg) was recorded in CM-16 (rainy) and 9.38 kg in CM-20 (summer season). CM-30, CM-7 and CM-16 were observed to be an early types in summer condition.

Bottle gourd

Wide variability was observed in the 20 genotypes (rainy season) and 26 lines (summer season). Days to first female flower opening ranged from 42.86(LS-14) to 56.3 in (LS-3). The lowest sex ratio was in LS-16 (5.36) and LS-19 (7.12) in rainy and summer season respectively. Days to first fruit harvest was ranged from 68.36 (LS-14) to 83.84 (LS-8). The highest number of fruits per plant was observed in LS-6 (18.00) and LS-20 (12.8) in rainy and summer season respectively.

Bitter gourd

Bitter gourd germplasm was collected and evaluated both in rainy (45) and summer season (76)

for yield and quality characters. The results revealed wide range of variability among the genotypes for almost all characters particularly with respect to fruit weight (85.36 to 231.58 g), number of female flowers per plant (56.17 to 183.6), number of fruits per plant (36.56 to 86.73). The early flowering was observed in MCC-2 in summer season, it took about 48.53 days for opening of first female flowers. Yield per plant ranged from 1.08 kg to 3.56 kg. The genotypes MCC-23 had recorded the highest yield (7.6 kg) and fruit weight (231.58 g.) in rainy season and MCC-2 recorded the highest yield (3.56 kg) with 156.3g fruit weight.

Vegetative propagation

Mission C: Rapid multiplication of propagules of fruit crops.

At CIAH, Bikaner

C 1. Standardization of plant propagation and root stocks in arid fruits

The propagation in arid fruits like aonla (*Emblica officinalis*), lasoda (*Cordia myxa*), pomegranate (*Punica granatum*) and tamarind (*Tamarindus indica*) was initiated at CIAH, Bikaner to standardize vegetative propagation technique for mass multiplication of these important arid fruits. The aonla, lasoda and tamarind were propagated by budding while pomegranate was propagated by cutting under mist unit.

Aonla

In case of aonla, the experiment was laid out to see the effect of filling mixture and type of polycontainers on seedling vigour and budding success. However, the patch budding was done from middle of June- Middle of July. The treatments comprised of nine filling mixture i.e. T1: Sand, T2: Sand + Sheep Manure (1:1), T3: Sand + Sheep Manure (2:1), T4: Sand + Sheep Manure (1:2), T5: Sand + FYM (1:1), T6: Sand + FYM (2:1), T7: Sand + FYM (1:2), T8: Sand + Compost (2:1), T9: Sand + Pond Soil + Compost (1:1:1) and four types of polycontainers i.e. PC1: Polythene bag (15 × 10 cm), PC2: Polythene bag (25 × 10 cm), PC3: Polythene bag (25 × 15 cm), PC4: Polythene tube (25 × 10 cm).

The data obtained under various treatments indicated that the seed germination varied from 69.09% to 82.76% under different filling mixture indicated that merely use of sandy soil is not a good filling mixture. Among polycontainers, bigger size of polybags had given better seed germination. Similarly, highest percentage seedling stock was also observed in big size of polythene bags (25 × 15 cm) filled with sand: pond soil: compost in the ratio of 1:1:1 respectively. The vigour of seedling stock was also measured in terms of seedling height and stock girth. It was found that the seedling vigour was poor in case sand mixture and it was better where either pond soil or manures were used as filling mixture. There was a wide variation in the height of the seedlings but variation in the stock girth was less under different treatments.

From the first year of observations, it was observed that the budding success was not very appreciable. The success of budding varied from 30.91% to 44.83%. Among various treatments, there was no much difference in success of budding, however, the lowest success was recorded when sand was used as filling mixture. This indicated that the vigour of rootstocks has some influence on success of budding in aonla. Among different polycontainers, the bigger size of polybags had given better

response than smaller size of polybags. The highest budding success (52.40 %) was recorded in 25 × 15 cm size of polybags filled with sand + pond soil + compost (1:1:1). However, in second year (2003) when budding was done in June, the success was better (Table 16) than budding from late July-August. Under T7 and T9, about 80% success was obtained. This suggested that budding from middle of June-middle of July is good for success of salable plants with desired growth.

Table 16. Effect of filling mixture and polycontainers on budding success (%) in aonla 2002-03

Treatment	Polythene bag (15 × 10 cm)		Polythene bag (25 × 10 cm)		Polythene bag (25 × 15 cm)		Polythene tube (25 × 10 cm)		Mean	
	2002	2003	2002	2003	2002	2003	2002	2003	2002	2003
T1	25.50	27.50	33.50	28.00	32.15	38.50	32.50	30.50	30.91	31.13
T2	27.60	38.50	37.00	42.50	36.50	67.45	36.15	41.00	34.31	47.36
T3	32.70	37.00	42.15	48.50	44.55	66.50	40.00	47.50	39.85	49.88
T4	33.00	44.00	46.00	55.05	47.55	71.50	44.00	58.25	42.64	57.20
T5	33.55	46.00	46.00	60.00	50.15	70.40	44.25	62.00	43.49	59.60
T6	32.80	43.55	45.00	50.00	48.50	69.50	43.25	49.50	42.39	53.14
T7	29.50	46.50	48.00	64.50	51.15	80.25	44.55	66.00	43.30	64.31
T8	34.50	43.00	49.50	50.00	50.00	68.50	43.50	53.25	44.38	53.69
T9	34.50	45.50	49.50	63.60	52.40	79.50	42.50	64.50	44.83	63.28
Mean	31.52	41.28	44.07	51.35	45.88	68.01	41.18	52.50	-	-

Pomegranate

The investigation on 'standardization of pomegranate (*Punica granatum* L.) propagation by cutting under mist system' was carried out at Central Institute for Arid Horticulture, Bikaner (Rajasthan) during 2002-2003. The treatments comprised of two types of cutting i.e. i) hard wood cutting and ii) semi-hardwood cutting; five concentrations of Indolebutyric acid (IBA) i.e. i) 50 ppm, ii) 100 ppm, iii) 200 ppm as prolonged dip (over night) and iv) 2500 ppm and v) 5000 ppm as quick dip (10 minutes) as well as vi) water dip (as control); planted at monthly intervals i.e. January to December. The observations revealed that pomegranate cultivar Jalore Seedless can be propagated both by hardwood and semi-hardwood cuttings under mist system though the better success was obtained with semi-hardwood cutting. The sprouting of cutting although pre-requisite for rooting but there was no direct relationship between sprouting and rooting of cuttings. Among various concentrations of IBA, 2500 ppm IBA had given best response in terms of rooting and number of roots/ shoot in semi-hardwood cutting but the same treatment did not make any impact with hardwood cuttings regarding percentage rooting. Appreciable response with respect to rooting was also recorded in control (water dip only)

during July in both type of cuttings indicated that microclimatic conditions have marked influence on rooting than exogenous application of IBA. The number of roots/ shoot were maximum at 2500 ppm in both type of cutting but length of roots reduced with increasing concentrations of IBA. July followed by August and September was the best months for planting of cuttings. From this investigation, it is concluded that pomegranate can be propagated successfully in the months of July-September under mist system by using both semi-hardwood cuttings (90.5 % rooting in July) and hardwood cuttings (80.5 % rooting in July) after treating with 2500 ppm IBA. This treatment (IBA-2500 ppm) also induces fibrous root system, which is essential for better establishment of plants under field conditions. The higher endogenous level of total protein content in hardwood cutting attributed relatively poor rooting than semi-hardwood cuttings, though the differences were marginal.

Tamarind

For vegetative propagation of tamarind (*Tamarindus indica*) under Bikaner conditions, scion buds taken from elite tree having tolerance to frost and superior in quality traits were patch budded on nine month old seedling root stock at fortnightly interval between June and October for two consecutive years. The results of the experimentation revealed that the time of budding significantly influenced the sprouting per cent, days taken to sprout, percentage graft success, survival, linear and radial growth (cm). Patch budding during 3rd week of July and first fortnight of August resulted in highest bud success (>75%) and survival (>70%) under arid environment of Bikaner.

C 2. Biotechnological approaches in mass multiplication

Under National Agriculture Technology Project, micropropagation protocol for ker (*Capparis decidua)* an important arid fruit crop developed. The percentage of explant establishment under *in vitro* condition with proliferation of shoot was noticed higher when explant taken from mother stocks during the month of August-September as compared to other month. The *in vitro* growth inhibitory factors such as endogenious level of phenolics and other C/N ratio was found higher during the period of May-July (>200 kg/g fruit).

The maximum shoot prolification was achieved on MS media supplimneted with 30 gm sucross, 2 mg/L BA + 0.1 mg/L/IAA.

The proliferted micro shoot of 20-30 cm long excised from the growing cultures and transfer into rooting media good adventifious roots were developed within 5-6 weeks on half strength of MS Medium supplenmented with 0.5 mg IBA + 0.5 mg NAA.

Another study was conducted on micropropagation of date palm. The shoot tip of 3-5 mm size isolated from the seedling plants of 2-3 months old. The shoot tip developed into rootable microshoot within 8-10 week when cultured on MS medium supplimented with 30 gm sucrose, 8 gm agar, 3 gm

activated charcol and 2.5 mg of NAA + 2.5 mg IBA/litre. The microshoot of date palm rooted on the MS medium supplimented with 3 mg/L NAA.

At CHES, Godhra

C 3. Propagation studies in Jamun and Tamarind:

Patch budding

Maximum success was recorded in the month of March (35.00 %) in jamun, while; it was found to be maximum (40.00 %)in the month of August in case of tamarind.

Soft wood grafting

Maximum success was recorded in the month of August (30.00 %) in jamun, while; it was found to be maximum (20.00 %)in the month of May in case of tamarind

Growth and development

Mission D. Growth and development of horticultural crops under abiotic stresses

D.1 Studies on growth and development of some cucurbit crops under water stress

Effect of water stress on dry matter partitioning in Watermelon (Sugar baby) and mateera (AHW 65).

A field experiment was conducted to study the effect of water stress on the dry matter partitioning in watermelon (Sugar Baby) and mateera (AHW 65) at 60 days after sowing. The water stress was imposed by providing different levels of irrigation to the crop. The various levels of irrigations applied were 2, 4, 6 & 8 irrigations in the whole life cycle of the crop. The data thus obtained are presented in Table 17&18. Perusal of data reveals that in water melon the dry matter production was as high as 66.04 g/ plant at 8 irrigations whereas it reduced to nearly 50% (37.19 g/ plant) when the level of irrigations were reduced to 6.

Table 17. Dry Weight (g/plant) of Water Melon cv. Sugar Baby at Different Irrigation Levels

Treatment	Dry weight (g)			
	Stem	Root	Leaf	Total
2 Irrigation	14.09	1.45	15.82	31.36
4 Irrigation	15.55	1.64	17.97	35.16
6 Irrigation	12.75	0.86	24.33	37.19
8 Irrigation	24.82	1.75	39.47	66.04

Table 18. Dry Weight (g /plant) of Mateera cv. AHW 65 at Different Irrigation Levels

Treatment	Dry weight (g)			
	Stem	Root	Leaf	Total
2 Irrigation	20.11	0.78	33.18	054.09
4 Irrigation	26.81	1.28	33.25	061.34
6 Irrigation	32.12	1.12	48.18	081.42
8 Irrigation	39.89	1.73	62.65	104.27

In case of mateera, the maximum dry matter was produced at 8 irrigations (104.27g/plant) which dropped to 81.42g/ plant when 6 irrigations were given and further dropped to 61.34 g/ plant when 4 irrigations were given. Showing thereby that the reduction in dry matter production was less in mateera as compared to water melon.

Effect of water stress on photosynthetic rate and stomatal resistance in water melon and mateera

Photosynthetic rate and associated parameters were recorded in the crop raised in field as above. Giving different levels of irrigation to the crop created the water stress. The data thus obtained is presented in table 19. Perusal of data reveals that in case of Mateera the photosynthetic rate was 25.30 μ mol/m^2/s which remained nearly same at 6 irrigation level also. However, thereafter the magnitude declined. Similar pattern was also observed in case of watermelon. The Pn was very high 29.04 μ mol/m^2/s at 8 irrigation which declined marginally at 6 irrigation level. However at 2 irrigation levels there was a drastic decrease in the photosynthetic rate.

Table 19. Photosynthesis and Stomatal Resistence (s/cm) in Watermelon & Mateera with different Irrigation levels at 60 days (μ mol/m^2/s)

Treatment	Photosynthetic rate (μ mol/m^2/s)		Stomatal Resistence (s/cm)	
	AHW 65	Sugar baby	AHW 65	Sugar baby
2 Irrigation	23.25	16.18	0.123	0.022
4 Irrigation	21.25	24.68	0.064	0.047
6 Irrigation	25.90	28.24	0.056	0.064
8 Irrigation	25.30	29.04	0.057	0.058

Screening parameters for stress tolerance

In a persuit to identify the parameters for stress tolerance various characteristics were studied in drought resistant and susceptible plants.

i) Germination per cent

The germination percentage in materials listed in table 20 were investigated in presence of water (control) and 1 MP PEG (stress) condition. It was observed that this parameter did not show much difference.

ii) Degree of leaf rolling

The observations were recorded in field under irrigated and stressed plants. The data presented in Table 21 reveals that in tolerant cultivars such as kachari and mateera the leaf rolling was upto 45%

under stressed condition whereas in susceptible cultivars the leaf rolling was more that 55% in both cultivars. Thus, this parameter can be employed to assess the nature of plant.

Table 20. Germination Per Cent

Plant Type	Control	Stress
Snapmelon AHS 10	092.65	90.20
Kachari AHK 200	100.00	98.00
Mateera AHW 65	047.50	44.50
Tinda	090.00	88.33
Musk Melon	097.33	95.00

Table 21. Leaf rolling 20 days after withholding of irrigation.

Variety	Irrigated (%)	Stressed (%)
Kachari	-	41.25
Mateera	-	43.00
Muskmelon	-	62.50
Watermelon	4.2	65.00

D 2. Studies on Physiological adaptations to water stress in arid fruit crops

During the period under report a total of 22 fruit species growing in Nursery block were analysed for Photosynthesis and associated parameters. The data thus generated is presented in Table 22. Perusal of table reveals that Pn rate was high in Khejri, Phalsa, Mulbury, Tamarind, Aonla, Pomegranate Boardi, Marula , Chinese jujube and pilu, however it recorded lowest rates in Lemon, Kinnow, Karonda, and Mango. The results showed that tolerant and moderately tolerant species had higher Pn rate as compared to susceptible cultivars. Similar results were also seen with respect to Stomatal conductance where too, the drought tolerant and moderately tolerant cultivars showed higher rate of stomatal conductance in arid ecosystem.

The results revealed that these two parameters may have potential to be predict the drought tolerant/ susceptible nature of the plant species.

Table 22. Photosynthetic rate, stomatal conductance, stomatal resistance and transpiration in selected tree species of arid ecosystem

S. No.	Plant sp.	Pn	Stomatal Conductance	Stomatal Resistance	Transpiration
1	Phalsa	07.500	03.581	0.2968	0.0450
2	Lemon	01.057	01.163	0.8672	0.0567
3	Khirni	03.447	02.410	0.4210	0.0867
4	Mosami	02.330	01.276	0.8070	0.0561
5	Kinnow	01.570	01.353	0.7387	0.0629
6	Jamun	03.630	01.301	0.7863	0.0529
7	Mulbury	07.630	03.211	0.3188	0.0655
8	Karonda	01.949	01.526	0.6564	0.0746
9	Gonda	04.056	03.295	0.3689	0.0567
10	Bael	03.207	02.687	0.3898	0.0696
11.	Khejri	10.353	05.822	0.1847	0.1473
12.	Tamarind	08.218	15.310	0.0656	0.1969
13	Pomegranate	04.885	04.359	0.2359	0.1315
14	Aonla	05.755	02.502	0.4089	0.0967
15.	Marula	07.050	04.415	0.2734	0.1149
16.	Boardi	11.17	04.621	0.2053	0.1023
17	Chinese jujube	13.85	06.256	0.1659	0.1075
18	Pilu	11.87	17.290	0.0927	0.2392
19	Fig	08.443	02.933	0.3351	0.0558
20	Gauava	03.426	01.248	0.8015	0.0431
21	Mango	02.088	01.599	0.6271	0.0649
22	Sapota	04.653	01.904	0.5292	0.0720

Water management

Mission E: Water management in arid horticultural crops.

At CIAH, Bikaner

E 1. Drip irrigation in perennial fruit crops

Pomegranate

The study was undertaken under National Network Project on Perennial Fruit Crops. The project was in operation from 1998 to 2002. Due to non-realization of yield potential of the crop, the project was extended for one more year as a Institute project The irrigation requirement of the plant for different crops was calculated according to FAO bulletin. The fertirrigation schedules were deployed as per technical programme. The fruits were harvested in the months of February.

Fruit yield: The pattern of yield (Table 23) revealed that maximum (38.50q/ha) was recorded in 0.90CPE irrigation level through drip and minimum (17.00q/ha) in 1.00CPE irrigation level through bubbler system. The fruit yield (34.50q/ha) recorded at 0.75 CPE was statistically at par with 0.90CPE irrigation level. Thereafter, the fruit yields recorded at 0.50 CPE through drip and 1.00CPE through bubbler system were significantly lower over 0.90 and 0.75 CPE through drip system. The nitrogen application through drip also responded the fruit yield and maximum fruit yield was observed at 75 percent recommended dose of nitrogen and it was significantly higher over 50% of RD and control treatments.

Table 23. The mean fruit yield of pomegranate, total water applied and water use efficiency as influenced by various treatments.

Treatment	Yield (q/ha)	% Increase in yield	Water use (cm/ha)	Water use efficiency (q/ha-cm)	Saving of water (%)
Irrigation					
0.90 CPE through drip	38.50	126	40	0.96	10
0.75 CPE through drip	34.50	103	30	1.15	25
0.50 CPE through drip	18.00	5	20	0.90	50
1.00 CPE through pipe	17.00	-	40	0.35	-

Water use efficiency: The plant water use efficiency under different fertigation systems was evaluated and data presented in table 23 revealed that mode and level of irrigation water has affected the

water use efficiency. The water use efficiency has increased by more than two and half times at 0.75CPE irrigation level through drip over 1.00CPE through pipe irrigation system. The highest WUE was estimated at 0.75 CPE through drip and then decreases significantly at 1.00CPE and 0.50CPE irrigation through drip system and 1.00CPE through pipe irrigation system. Overall results revealed that under drip system the water use efficiency of the plant is better over pipe irrigation system. It is obvious that under drip irrigation system water losses through evaporation and deep percolation is much lower than pipe irrigation.

At CHES, Godhra

E 2. Soil and Water Conservation in Watershed Management.

1. Water scenario in CHES watershed

Location and the area:

CHES watershed is located at an elevation of 110 to 115 m above mean sea level having a latitude of $73^0\ 33'\ 22''$ N and longitude of$22^0\ 41'38''$ E. Its topography is rolling to level surface located in the forks of Central Gujarat. All small drainage meets to the Ruparail Nalla and this Nalla meets to the Goma river and Goma river meets to the Mahi basin. Four small drainage flowing from main research farm area of watershed to the south to north direction. Land use/ Land cover details of the watershed are presented in the following table.

Area under different land use/ Land covers in the CHES watershed.

Land Use/ Land cover	Area (ha)	Area (% of total)
Horticulture	071.00	21.00
Waste /Fallow land	166.00	49.12
Roads	010.00	02.95
Stony land	008.00	02.30
Small Gullies	034.00	10.05
Scrub land	030.00	08.87
Water bodies	015.00	04.43
Farmstead	004.00	01.18

Water availability

Rainfall (in the form of surface run off and ground water) are the major sources of water available at CHES watershed. The water availability in the watershed was assessed on monthly basis through direct measurement using of appropriate model and available database.

Analysis of Rainfall at CHES, Watershed

Water scarcity is increasingly becoming apparent. Rainfall analysis has been made to estimate occurrence of drought watershed of 21 years. Analysis shows that mean annual rainfall of watershed 714.63 mm with 81 per cent variation. The study reveals that 75 per cent of the years were drought, 18 per cent normal and 7 per cent surplus years implying that there is a likelihood of one drought year in a four years span. In a period of 21 years, 50 per cent months of monsoons seasons (June September) were drought months. Probability analysis of drought months indicates that in any year, there are strong chances of occurrences 9 drought months with 80 per cent probability. It was found that July was the wettest (252.25 mm) followed by August (224.65 mm). Total annual rainfall shows the peak value (1752.81 mm) and lowest value (194.20 mm) in the year 1990 and 2000 respectively.

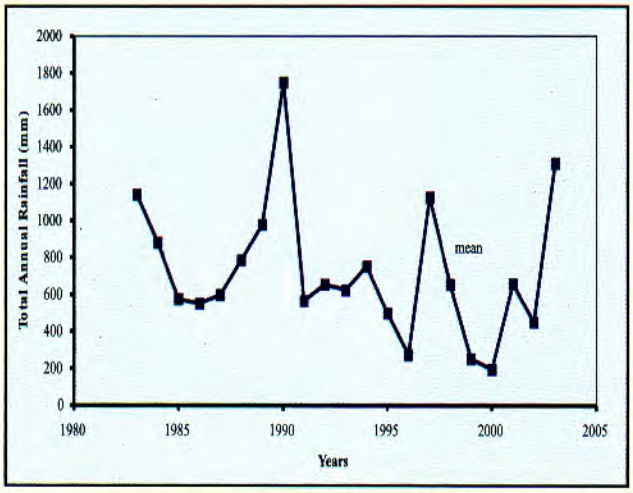


Fig. 5. Total Annual Rainfall at CHES Watershed

Infrastructure Development

The water harvesting system was incorporated to catch and collect rainwater into the reservoir.

Earthen Dam

It was constructed to harvest and store surface run off for farm uses, irrigation, moderation of floods, store sediment and impact on water stress through its on sites and off site effects. It is an earthen embankment constructed across a watercourse with adequate emergency spillway to protect the dam from failure by overtopping of excess stream flow.

Empty Cement Bag Filled with Locally Available Sand

It was constructed to harvest seepage water from the upper side of check dam and store surface runoff for farm uses, irrigation, store sediment and impact on water stress through its on sites and off

sites effects. It is a *kachha* check dam constructed across a watercourse.

Drainage

A drainage system for the experimental plot was built to carry rainwater out of the farm area so that no water logging occurs even during very high precipitation and constructed two ponds for collecting actual soil loss from the experimental plot. The water and soil collected in the ponds will be used for irrigation purpose and sedimentation analysis.

Integrated nutrient management

Mission F: Integrated nutrient management in horticultural crops

At CIAH, Bikaner

F.1 Response to substitution of manures and fertilizers with vermi-compost to the growth and fruit production of crops.

Growth and production of pomegranate (*Punica granatum*) fruit crop with organic and inorganic farming.

As per technical programme, the recommended doses of NPK for seven-year-old plant has been worked out. On the basis of nitrogen content in different types of manure, amount of cattle manure, sheep manure and vermicompost per plant per year has been calculated. All ten treatments along with control (N_0, P_0, K_0) were tried in factorial randomized block design.. The treatments comprised of i) sheep manure (SM) @ 21.5 kg/plant; ii) cattle manure (CM) 28.5 kg/plant; iii) vermi-compost @ 15 kg/plant; iv) inorganic fertilizers (IF) through urea, single super phosphate and muriate of potash; v) CM: SM in 50:50 ratio; vi) CM: VC in 50:50 ratio; vii) CM:IF in 50:50 ratio; viii) SM: VC in 50:50 ratio, ix) SM:IF in 50:50 ratio; x) VC:IF in 50:50 ratio and xi) control (NoPoKo) in the month of June, 2003. The growth parameters like plant height, plant spread and tree volume was recorded in every month. The leaf sample for nutrient analysis were collected in the month of September, 2003 and analyzed for N, P, K, Ca, Mg, Zn, Cu, Mn & Fe nutrients following the standard procedures. The physiological activities of the plant were measured during fruiting stage and soil moisture contents were measured in September and October 2003 to monitor the moisture retention in different treatments.

During the year 2001 and 2002, *mrig bahar* crops were harvested. For *mrig bahar* crop, the water was with hold in the months of April and May and flowering was allowed in the first week of July. The crops were harvested in the month of December. In both the years, it has been observed that fruit cracking was upto the extent of 60-70 per cent. During the year 2002 the cracking behavior was studied more critically and some plant beside the experiment were allowed to flower in the first week of October and fruits were harvested in the month of February and observed that only 3-5 percent fruits have been cracked. In both the crops i.e *mrig bahar* and October fruit set crop, moisture was controlled through drip irrigation.

In view of the above observations, during the year 2003-2004, water was withhold in the month September, 2003 and flowering was allowed in the month of October 2003 in all experimental plant and

crop was matures in the month of February 2004 The observation on cracking, average fruit weight, fruit yield, fruit quality such as juice acidity, total soluble solids and ratio of TSS and juice acidity were measured in February 2004. The soil samples were collected from all treatments and analyzed for fertility build up especially with regards to organic carbon, available, nitrogen, phosphorus and potassium in October 2003. The average monthly temperatures, humidity, rainfall and evaporation from September 2003 to March 2004 were also recorded.

Fruit Cracking

The extent and pattern of fruit cracking in different treatment was observed. The data pertaining to extent of cracking revealed that in all treatments including control, the cracking was in the tune of 3-8 per cent however, among the different treatments, differences were not significant. Pattern of cracking in different treatments was also observed and it was noticed that in all treatments among the cracked fruits 80-85 percent fruits were cracked vertically while in remaining fruits, the cracking was mixed (vertical/horizontal/zigzag) in pattern. It was also noticed that cracking mostly starts after 75 to 85 days after setting.

Plant growth

The growth was measured monthly interval but in report the growth measured in the month of December 2003 have been presented in table 24. The mean plant height data was in the range of 1.65 to 2.40 m and maximum plant height was recorded in T_{10} treatment and it was statistically at par with T_1, T_3, T_6 and T_8 treatments. The percent increase in plant height over control treatment was also worked out. Data revealed that maximum increase (48.50%)was estimated in T_{10} and minimum (12.15 %) in T_4 treatment over control treatment (T_{11}).

The plant spread was also measured every month and in report, the data pertain to December 2003 months have been given. The data presented in table 24 revealed that maximum tree spread (2.25 × 2.65m) was recorded in T_{10} followed in T_3 T_1, T_8 that were statistically at par while other treatments (T_2, T_4, T_5, T_6, T_7, T_9 and control) are significantly lower over T_{10}, T_3, T_1 and T_8 treatments. The minimum spread (1.25 × 1.40m) was recorded in control. Data also revealed that plant spread was more in E-W direction in comparison to N-S direction.

Fruit weight

In pomegranate crop, fruit weight is also an important character and was recorded at the time of harvest of the crop in each treatment. The data presented in table 25 revealed that fruit weight in different treatments was in the range of 210 to 350 g and average maximum fruit weight (275 g) was recorded in T_{10} and it was statistically par with T_1, T_3, T_6 and T_8 treatments and average minimum fruit weight (210 g) was recorded in T_{11} treatment (control).

Table 24. Effect on plant growth parameters to integration of manures and fertilizers

Treatment	Plant height		Plant spread (m)	
	(m)	% Increase	E-W	N-S
T1	2.30	40.00	2.20	2.15
T2	2.20	33.00	2.20	2.15
T3	2.40	45.46	2.20	2.50
T4	1.85	12.15	1.85	2.00
T5	2.25	36.40	2.20	2.25
T6	2.40	45.45	2.10	2.30
T7	2.15	30.30	2.10	2.10
T8	2.35	42.25	2.20	2.25
T9	2.20	33.30	2.00	2.10
T10	2.45	48.50	2.25	2.65
T11 (control)	1.65	-	1.25	1.40
SEm±	0.13	-		
CD (5%)	0.28	-		

Fruit yield

The data pertain to average fruit yield (q ha^{-1}) have been presented in table 25. The data revealed that fruit yield was found in the range of 24.5 to 44.00 q ha^{-1}. The maximum and significantly higher fruit yield (44.00 qha^{-1}) was recorded in T_{10} treatment and which was statistically at par in T_1, T_3, T_8 and T_6 treatments and minimum fruit yield was recorded in control treatment. The increase in fruit yield in different treatments over control was also estimated and found that maximum (79.60%) increase in fruit yield was recorded in T_{10} treatment while minimum increase over control was estimated in T_4 treatment.

Fruit quality

The fruit quality of pomegranate is also being evaluated (Table 26). The total soluble solids, juice acidity and their ratios were estimated in different treatments. The total soluble solids in different treatments were in the range of 15.00 to 17.50 degree brix. The maximum TSS content (17.50 ° brix) was estimated in T_3, T_6, T_8 and T_{10} treatments and minimum TSS was estimated in T_{11} treatment. Overall data revealed that total soluble solids were statistically at par in all treatments. The fruit juice acidity was estimated in different treatments and was found in the range of 0.15 to 0.25 percent. The minimum juice acidity (0.15 per cent) was recorded in T_8 treatment and maximum (0.25%) in T_{11} (control) treatment. Although juice acidity in T_3, T_6, T_8 and T_{10} treatments were statistically at par. The ratios of

these two parameters i.e. TSS and juice acidity were also estimated to evaluate the fruit quality and data shows that this was in the range of 65.00 to 140.00 and the maximum value (140.00) was observed in T_8 treatments while it was minimum in T_{11} treatment. Lower values of TSS/Acidity reflect the poor quality of fruits while higher values shows the additive factor of fruit quality.

Table 25. Effect on fruit and fruit yield to integration of manures and fertilizers

Treatment	Average Fruit Weight	Fruit Yield	
	(g)	(q ha-1)	% Increase
T1	280	35.00	42.85
T2	275	33.00	35.00
T3	325	41.50	70.00
T4	240	28.00	15.00
T5	290	35.00	42.85
T6	290	33.00	35.00
T7	285	30.00	22.50
T8	350	38.50	57.15
T9	270	30.50	24.50
T10	375	44.00	79.60
T11	210	24.50	-
SEm±	10.50	01.85	-
CD (5%)	31.33	04.12	-

Table 26. Response of different manures and fertilizers to TSS, Acidity and TSS/Acidity of pomegranate fruits

Treatments	TSS (° brix)	Juice acidity (%)	TSS/ Acidity
T1	17.5	0.19	0 92.1
T2	17.0	0.19	089.5
T3	15.0	0.15	100.0
T4	17.0	0.22	077.3
T5	17.0	0.20	085.0
T6	17.0	0.18	094.5
T7	16.0	0.16	100.0
T8	17.5	0.15	103.0
T9	16.0	0.20	080.0
T10	17.5	0.16	110.0
T11	15.0	0.25	060.0
SEm±	-	0.007	008.25
CD (5%)	NS	0.022	024.82

Leaf mineral composition

The data regarding leaf mineral composition are given in table 27. The data revealed that the nitrogen content was in the range of 1.85 to 2.70% and maximum N content was recorded in T_{10} and T_8 and minimum in T_{11} treatment. The P content was in the range of 0.19 to 0.25%. The maximum P content was estimated in T_3, T_6 and T_8 treatments. Except control treatment, other treatments were having the P content near to the maximum P content. The K content was found in the range of 1.65 to 1.78% and maximum K content was recorded in T_3 treatment and minimum K content was estimated in control treatment. Among the micronutrients, Zn, Cu, Mn and Fe contents were measured and data presented in table 27 revealed that zinc was in the range of 32 to 45 ppm and maximum Zinc content was measured in T_8 treatment and minimum in T_2, T_7 and control (T_{11}) treatments. The Copper content was more or less same in all treatments. The iron content was in the range of 50 to 65 ppm. The maximum iron content was observed in T_{10}, T_3 and T_7 treatment while minimum was in control treatment. The Manganese content was in the range of 40 45ppm and results revealed that in all treatments, the level of Mn is more or less same.

Table 27. Effect on concentration of macro and micro nutrients to different sources of manures and fertilizers

Treatment	Macronutrients					Micronutrients			
	N	P	K	Ca	Mg	Zn	Cu	Mn	Fe
	(%)					(ppm)			
SM	2.25	0.24	1.75	2.35	0.30	35	4	45	70
CM	2.30	0.24	1.70	2.35	0.25	32	4	40	60
VC	2.65	0.25	1.78	2.55	0.35	40	4	50	75
IF	2.50	0.25	1.65	2.05	0.20	35	4	40	60
CM:SM	2.35	0.24	1.60	2.45	0.25	38	4	40	70
CM:VC	2.55	0.25	1.75	2.45	0.26	40	4	45	80
CM:IF	2.25	0.24	1.70	2.50	0.00	32	3	40	75
SM:VC	2.70	0.25	1.70	2.45	0.25	45	4	50	55
SM:IF	2.35	0.24	1.75	2.35	0.20	38	3	40	60
VC:IF	2.70	0.25	1.70	2.45	0.25	41	4	50	75
Control	1.85	0.20	1.65	2.00	0.18	32	3	40	52

Physiological activity

The physiological parameters like photosynthetic activity, transpiration rate, water use

efficiency; stomata conductance and stomata resistance were measured during fruiting stage. Data given in table 28 revealed that photosynthetic activity (P_N) was recorded in the range of 0.4200 to 0.6500 mg CO_2 m^{-2} s^{-1}. The maximum P_N activity was recorded in T_8 followed in T_3 (0.6500 mg CO_2 $m^{-2}s^{-1}$), T_6 (0.570 mg CO_2 $m^{-2}s^{-1}$). The minimum activity (0. 4200 mg CO_2 m^{-2} s^{-1}) was recorded in T_4 and T_{11} treatment.

The transpiration rate was recorded in the range of 1.250 to 1.560 mg H_2O m^{-2} s^{-1}. The mean maximum transpiration rate (1.560 mg H_2O $m^{-2}s^{-1}$) was recorded in T_{11} treatment followed in T_1 (1.250 mgH_2O $m^{-2}s^{-1}$) and T_8 and T_6 treatments (Table 34) and minimum water transpired (1.250 mg H_2O m^{-2} s^{-1}) was in treatment T_{10} followed inT_8, T_2 T_3 and T_6 treatments. The maximum water use efficiency (52.50%) was estimated in T_8 treatment followed in T_{10}, T_3, T_6 and T_5 treatments. The minimum water use efficiency (25.5%) was recorded in T_{11} control treatment.

The stomatal resistance was ranging to 0.450 - 0.600 s cm^{-1}. The minimum stomata resistance was observed in T_3 followed by T_8 and T_{10} treatment and maximum resistance was found in T_4 followed by T_9 treatments. Stomata conductance was in the inversely proportionate to resistance values and stomata conductance was observed in the range of 1.70 to 2.22 cm s^{-1}.

Table 28. Effect of manure and fertilizers on physiological activity of pomegranate plant

Treatments	PN (mg $CO_2m^{-2}s^{-1}$)	Transpiration rate (mg $m^{-2}s^{-1}$)	Water use efficiency (%)	Stomatal resistance resistance (s cm^{-1})	Stomatal conductance (cm s^{-1})
SM	0.5830	1.250	46.65	0.500	2.00
CM	0.5600	1.265	44.27	0.500	2.00
VC	0.6400	1.270	51.20	0.450	2.22
IF	0.4200	1.320	31.82	0.590	1.70
CM: SM	0.5565	1.350	41.22	0.530	1.89
CM: VC	0.2630	1.250	47.68	0.455	2.20
CM:IF	0.5000	1.260	39.68	0.550	1.82
SM: VC	0.6300	1.250	50.04	0.455	2.20
SM:IF	0.5665	1.255	45.14	0.580	1.72
VC:IF	0.6500	1.200	54.16	0.460	2.17
Control	0.4200	1.560	26.92	0.560	1.79
SE±	0.0613	0.093	04.98	-	-
CD (5%)	0.1392	0.255	10.52	NS	NS

Soil moisture status

The retention and depletion of soil moisture has been studied in different treatments. The profile soil moisture up to the depth of 1.00m was recorded with the help of TDR meter. During soil moisture study main emphasis was given to retention capacity of soil moisture under different treatments and moisture depletion from different layers of the soil. The moisture data was recorded after 5 days of saturating the soil profile. Data of soil moisture revealed that maximum soil moisture (11.5-12.6%) up to the depth of 30cm was recorded in T4 treatment and minimum soil moisture (5.2-6.4 %) at the same depths was observed in control treatment. The pattern of depletion revealed that the maximum moisture depletes from 20-24cm soil profiles in T1, T2. T3, T6, T8 and T10 while in T4 and T11 the depletion was from 10-20cm depths.

The depletion in moisture was more and fast in control and inorganically fertilized treatments while in organically treated cases, the depletion was slow and gradual. Thus, organic material helped in checking soil moisture losses especially in root zone.

Soil fertility builds up

To monitor the changes in pH, organic carbons, available N, P, K over the time due to application of different types of manures and inorganic fertilizers, soil samples were collected in each yeas from each treatment (Figure 6). The samples were analyzed for organic carbon, available nitrogen, phosphorus and potassium content. The organic carbon content was only 0.09 per cent and reached to 0.28 per cent after five years. The maximum organic carbon (0.28%) was estimated in T_3, T_5, T_6 and T_8 treatments. In control treatment, the organic carbon content was recorded lower (0.08%) than initial organic carbon (0.09%). The available N content has been increased in all treatments except control where the value was more or less same as initial value. The maximum available nitrogen build up was observed in T_{10} followed in T_4. The available P content was only 12.5 kg/ha before deployment of treatments and reached maximum (23.0 kg ha^{-1}) in T_{10} treatment while in control treatment the status of available P has gone down in comparison of initial level. The available potassium content also increased in all treatment except control one. The K content has increased from 190.6 kg ha^{-1} to 235 kg ha^{-1} in T_{10} treatment followed in T_3 and T_8 treatments(Table 29 and Fig. 6).

F 2. Nutrient management in fruit crops- aonla and sapota

Developing DRIS norms in Sapota and Aonla.

A leaf sampling survey in sapota was conducted in Gujarat state. About sixty samples were collected and samples were analyzed for their nutritional status and chemical nature.

Table 29. Changes in organic carbon, available N, P, K contents over the three period.

Treatments	Organic carbon (%)	Available N (kg ha^{-1})	Available P (kg ha^{-1})	Available K (kg ha^{-1})
T1	0.23	195	18.0	215
T2	0.22	190	18.0	220
T3	0.28	198	20.0	230
T4	0.10	182	16.5	200
T5	0.28	185	16.0	215
T6	0.28	190	17.5	218
T7	0.20	185	16.0	215
T8	0.28	195	17.0	225
T9	0.20	180	17.0	220
T10	0.20	198	23.0	235
T11	0.08	135	11.0	190
Initial level	0.09	125.6	12.5	186.4

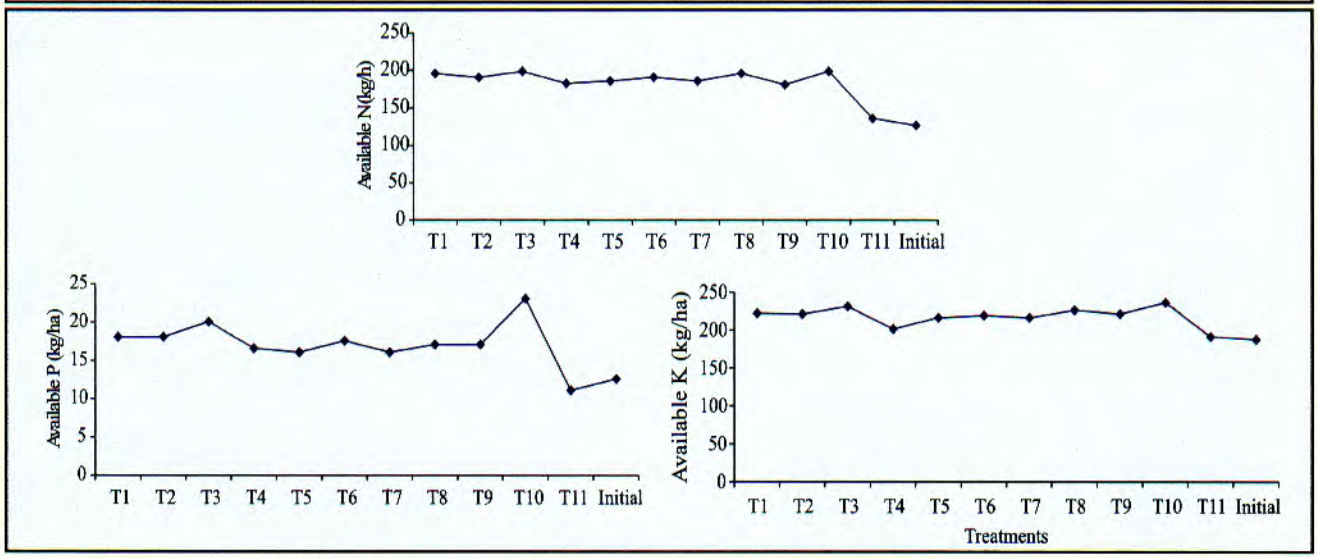


Fig.6. Changes in available N, P & K under different treatments.

At CHES, Godhra

A leaf sampling survey in Sapota was conducted in Gujarat State. About sixteen samples were collected & samples were analysed for their nutritional status and chemical nature.

The individual nutrient concentrations in the leaf from high yielding population are classified in to low, optimum and high based on standard deviation (SD) for developing DRIS. 4/3 SD is taken in to criteria for classifying the nutrient concentrations. The nutrient concentrations with mean + 4/3 SD to

mean - 4/3 SD are optimum, < mean 4/3 SD are low and > mean+ 4/3 SD are high.

The classification of nutrient norms for sapota from high yielding population is presented in Table 30. The optimum values for nitrogen ranged from 1.25-2.38%, where for Phosphorus, Potassium, Calcium, Magnesium, and Sulfur the optimum values are 0.05-0.17%, 0.36-0.77 %, 1.01-2.04%, 0.48 0.92% and 0.38-0.82% respectively.

Table 30. Nutrients Norms of Sapota for Nitrogen, Phosphorus, Potassium, Calcium, Magnesium and Sulphur.

NUTRIENT	LOW	OPTIMUM	HIGH
NITROGEN	<1.25	1.25-2.38	>2.38
PHOSPHORUS	<0.05	0.05-0.17	>0.17
POTASSIUM	<0.36	036-0.77	>0.77
CALCIUM	<1.01	1.01-2.04	>2.04
MAGNESIUM	<0.48	0.48-0.92	>0.92
SULPHUR	<0.38	0.38-0.82	>0.82

Electrical conductivity of soils of Sapota orchard ranged from 0.049 to 9.3 dSm^{-1} (0.967), P^H ranged from 7.32 to 8.84 (8.18), Phosphorus status ranged 1.4 to 83.6 ppm (18.6), Potassium ranged from 11 to 965 ppm (198.1), Calcium content ranged from 834 to 14314 ppm (4482.4), Magnesium ranged from 174 to 3206 ppm (1447.6) and Sulphur ranged from 11 to 583ppm (61.8). These results will be used for developing DRIS norms.

N, P, K trials in Sapota:

From the N P K trials in Sapota it has been observed that Maximum plant height (300 cm) and spread (340.7 cm in NS direction) was observed in the treatment receiving 500g Nitrogen/tree. In case of potassium trials significant response was observed in case of treatment receiving 400g K_2O / tree and it was reflected in height (360 cm) and spread (410 cm in EW direction and 445 cm in NS direction).

Aonla

Another leaf sampling survey was done in 2003 in Uttar Pradesh State. Soil samples have been analysed for their nutritional status and chemical nature. The soil analysis part reveals that Electrical conductivity of the collected soil samples ranged from 0.028 to 0.330 dSm^{-1} (0.089), P^H ranged from 6.13 to 8.75 (7.3), Organic carbon ranged from 0.2 to 0.89 % (0.47), Olsen's Phosphorus ranged from 0.2 to 51.6 ppm (14.8), Exchangeable Potassium ranged from 26.8 to 206.5 ppm (79.3), Exchangeable Calcium ranged from 102.2 to 12224 ppm (1426.8), Exchangeable Magnesium ranged from 170.1 to 14948 ppm (850.1), Calcium chloride (0.15%) extractable Sulphur ranged from 4.2 to 86.5 ppm (40.9).

Planting Models and Agrotechniques

Mission G: Development of planting models and agrotechniques in horticultural crops for arid ecosystem

G.1 Multistrata aonla based cropping system

Establishment, growth and survival of main and understorey crops

Multistorey aonla based cropping system studies with six different cropping models viz., Aonla+ber+brinjal+mothbean+cumin (Model I); Aonla+bael+brinjal+moth bean+cumin (Model II), Aonla+ber+karonda+mothbean+cumin (Model III); Aonla+bael +karonda+mothbean+cumin (Model IV); Aonla + drumstick + saji + mothbean + cumin (Model V) and Aonla + khejri + saji + mothbean + cumin (Model VI) was initiated during the year 2002 in RBD with three replications.

Data with respect to establishment, survival and growth parameters of main and component crops were recorded at six monthly interval during August 2003 and Feb 2004. Plant establishment in the perennial components viz., aonla, bael, ber, khejri, drumstick, karonda and saji (*Suaeda fruticosa*) was recorded to be cent per cent. Similarly, 100% plant survival was recorded in all the perennial components except bael (*A marmelos*) and aonla (*E. officinalis*) in which the plant survivals were recorded to be 98.0 and 95.0 per cent respectively (Table 31).

Table 31. Establishment, survival and growth of main and component crop planted *in situ* in the cropping system

Crop	Establishment (%)	Survival (%)	Pl.ht (cm)	St. girth (cm)
Aonla	100	95	53.0	1.02
Bael	100	98	20.0	0.80
Ber	100	100	32.5	1.00
Khejri	100	100	29.0	0.74
Drum stick	100	100	45.0	0.65
Karonda	100	100	35.0	0.55
Saji	100	100	52.0	0.70

Average plant height recorded in the different perennial component crops was recorded to be maximum in aonla 53.0cm followed by saji (52.0 cm) ber (32.50cm), khejri (29.0 cm), while it was

lowest in bael (20.0cm). The other growth parameter i.e., stem girth was found to be maximum in base crop aonla (1.02 cm) which was marginally equal to ber (1.00cm) followed by bael (0.80 cm), khejri (0.74 cm).

Production of ground storey crops in aonla based cropping system

Brinjal grown as a seasonal ground storey component between two aonla plants spaced 8m apart at a spacing of 60×40cm leaving 1m away from the main trunk, thus occupying 6m^2 area between two aonla plants recorded an average yield of 19.63 and 20.38 q ha^1 in models I and VI respectively as compared to control (10.19 q ha^{-1}). Mothbean grown as a common ground storey crop during Kharif 2003 in the interspaces of aonla plants spaced 8x8 m apart and occupying 50% area in all the cropping models recorded higher yield as compared to control (Table 32). Maximum moth bean yield was recorded in model III (4.83 q ha^{-1}) followed by Model I and IV (4.52 q ha^{-1}), Model V (4.25 q ha^{-1}), Model II (4.15 q ha^{-1}). Although lower yield was recorded Model VI (3.99 q ha^{-1}), it was higher than control.

Table 32. Production (q ha^{-1}) of ground storey crops in aonla based cropping system

Model	Brinjal	Mothbean	Cumin	Saji
I Aonla-Ber-brinjal-mothbean-cumin	19.63	4.52	3.00	--
II Aonla-Bael-Karonda-mothbean-cumin	--	4.15	2.75	--
III Aonla-khejri-saji-mothbean-cumin	--	4.83	2.50	1.20
IV Aonla-drumstick-saji-mothbean-cumin	--	4.52	2.70	1.10
V Aonla-ber-karonda-mothbean-cumin	--	4.25	3.00	--
VI Aonla-bael-brinjal-mothbean-cumin	20.38	3.99	2.50	--
Control	10.19	3.01	2.00	1.10

Cumin grown as a *rabi* ground storey crop in the inter space of aonla plants thus occupying 50% area was harvested during last week of March and data with respect to yield were recorded. Yield was observed to be 33.33% more in Models I and V followed by 27.27% in model II, 25.92% in model IV and 20% in models III and VI respectively over control. Saji (*Suaeda fruticosa*) twigs were harvested in January and processed for extracting the salt. From a biomass of 5 Kg harvested twigs, the salt recovery was to the tune of 4-6%.

Biomass productivity under different cropping model

Maximum biomass productivity was recorded in brinjal crop followed by mothbean, saji and cumin under different cropping models. Brinjal biomass yield was 8.70 q ha^{-1} in model I and 8.65 q ha^{-1} in model 6, both were higher over control (5.08 q ha^{-1}). Biomass productivity of moth bean varied between 13.18 q ha^{-1} (control) to 15.70 q ha^{-1} (model 5) and it was higher in all the cropping models as

compared to control. Biomass productivity in cumin ranged from 3.20 q ha^{-1} in model II to 3.75 q ha^{-1} in model V. Minimum cumin biomass yield was recored in control (2.35 q ha^{-1}). Not much differences were observed with respect to the biomass of yield of saji (*S.fruticosa*). However, it was maximum in model III (30.00 q ha^{-1}) followed by model IV (28.00 q ha^{-1}) and was at par to control (Table 33)

Table 33. Biomass productivity (q ha^{-1}) under different cropping models.

Model	Brinjal	Mothbean	Cumin	Saji
I Aonla-Ber-brinjal-mothbean-cumin	8.70	15.50	3.64	--
II Aonla-Bael-Karonda-mothbean-cumin	--	15.00	3.20	--
III Aonla-khejri-saji-mothbean-cumin	--	15.00	3.50	30.00
IV Aonla-drumstick-saji-mothbean-cumin	--	15.30	3.60	28.00
V Aonla-ber-karonda-mothbean-cumin	--	15.70	3.75	--
VI Aonla-bael-brinjal-mothbean-cumin	8.65	14.25	3.25	--
Control	5.08	13.80	2.35	28.00

Gross return from the different cropping model

Economics of different cropping models for ground storey crops was worked out (Table 34). Maximum gross return of Rs 28,861 ha^{-1} was obtained in model I in which the crop combinations were Aonla-Ber-brinjal-mothbean-cumin followed by model VI Rs. 28,861 ha^{-1} in which Aonla-bael-brinjal-mothbean-cumin were grown in association. In other models, the gross return varied between Rs 20, 793 to Rs 22, 675 ha^{-1}.

Table 34. Gross return (Rs ha^{-1}) under different cropping models.

Model	Brinjal	Mothbean	Cumin	Saji	Total
I Aonla-Ber-brinjal-mothbean-cumin	5889	4972	18000	--	28861
II Aonla-Bael-Karonda-mothbean-cumin	--	4565	16500	--	21065
III Aonla-khejri-saji-mothbean-cumin	--	5313	15000	480	20793
IV Aonla-drumstick-saji-mothbean-cumin	--	4972	16200	448	21172
V Aonla-ber-karonda-mothbean-cumin	--	4675	18000	--	22675
VI Aonla-bael-brinjal-mothbean-cumin	6114	4389	15000	--	25503
Control	3057	3311	12000	448	--

Physico-chemical changes in soil properties of brinjal plot grown under mulch treatment.

The Physico-chemical properties of the soil were analysed after harvesting of brinjal crop grown under different mulch treatment viz., leaves of lasoda (*C. myxa*), neem (*A. indica*), grass

clippings of sewan (*L. sindicus*), Kheep (*L. pyrotechnica*) and white and black polyethylene mulches for two consecutive years. Higher content of soil potassium was recorded under both organic and synthetic mulches (Table 35).

Table 35. Physico-chemical properties of soil of brinjal plots under mulch treatment.

Treatment	Texture	Bulk ensity g cm^{-3}	PD	pH ($g\ cm^{-3}$)	EC	Org. C (%)	CaCO dS m^{-1} (%)	Av. nutrients (Kg ha^{-1}) N	P_2O_5	K_2O
Control	Sand	1. 58	2.78	8.6	0.163	0.031	2.0	104	10	534
C myxa leaves	Sand	1. 58	2.77	9.1	0.141	0.040	1.5	89	12	367
A. *indica* leaves	Sand	1. 58	2.76	8.5	0.162	0.040	1.0	103	12	345
L. *sindicus* clippings	Sand	1. 59	2.79	8.4	0.150	0.035	1.5	102	12	295
L. pyrotechnica clippings	Sand	1. 58	2.76	8.4	0.128	0.033	1.5	102	12	290
W. polyethylene	Sand	1. 57	2.76	8.6	0.161	0.032	4.0	90	11	280
B. polyethylene	Sand	1. 59	2.78	8.6	0.178	0.032	4.0	94	11	289

Although the amount of free calcium carbonate was reduced under organic mulches, it remained unchanged under synthetic mulch treatment. Similarly, no noticeable changes were recorded in case of bulk density, particle density, texture, structure, EC, pH, organic carbon and available N and P content of soil.

At CHES, Godhra

G.2 Standardization of Agro-techniques on some semi arid ruits.

Effect of bio fertilizers on growth, yield and quality of pomegraante cv. Ganesh.

Application of Azospirillium culture with phosphate solublizing bacteria @ 50g each was found to increase retention of fruits (80.5) and yield/plant (10.06 kg). Vegetative growth parameters were however not influenced.

Effect of organic and in organic sources of N on growth, yield and quality of pomegranate cv. Ganesh.

Application of fertilizers in the organic and inorganic form along with their combination does not influence the vegetative growth parameters Maximum number of fruits retained (106/plant) and subsequently yield per plant (13.25 kg) was obtained in Nitrogen application 50% through FYM, 25% through Castor cake & 25% through Urea.

High-density Orcharding in Ber

High-density orcharding in ber with four varieties viz., Umran, Gola, Seb, Mundia revealed that most of the vegetative growth parameters were not influenced by either spacing of variety in 10 years old ber orchard. Whereas, yield per plant & per hectare were significantly influenced by the spacing as well as variety. Maximum yield/plant was recorded in cv. Umran with 10x10m spacing. However it was maximum in variety Umran at 5x5m spacing on hectare basis. Physico-chemical analysis of the fruit showed significant influence on fruit weight, fruit diameter, fruit length, pulp stone ratio and TSS. Thus growing ber cv. Umran at 5x5m spacing under rainfed conditions was the best for obtaining commercial crop of ber.

High density Orcharding in Aonla

Aonla cv. NA-7 is found to be dwarf as compared to others. The results of high-density experiment revealed that vegetative growth parameters did not differ significantly. Fruit retention/shoot was higher in 10x10m spacing whereas yield /ha was highest in 5 x5m spacing.

G.3 Standardization of production technology of aonla (*Emblica officinalis* Gaertn).

Effect of different mulches on soil properties, growth, yield and quality of aonla.

Results of the study revealed that organic and inorganic mulching treatments (paddy straw, maize straw, grasses, subabool loppings, rice husk, and black polythene) encouraged plant growth and reduced soil moisture evaporation than control. Among the various mulches tried, maximum plant height (2.34 m), root stock girth (12.47 cm), scion girth (10.05 cm) and plant spread (E-W =1.65 m. and N-S=1.60 m.) were recorded with black polythene mulch, while minimum was recorded in control. Among the organic mulches, maximum plant height (2.22 m), root stock girth (11.46 cm), scion girth (9.45 cm.) and plant spread (E-W=1.49 m. and N-S=1.67 m) were recorded with paddy straw closely followed by maize straw, greases and subabool loppings.

Physico-chemical properties of soil studied showed considerable improvement with respect to soil properties. Among all the organic mulches paddy straw exhibited better response followed by

maize straw, grasses and subabool loppings. Mulching with paddy straw showed maximum reduction in pH, ECe, ESP values followed by maize straw, grasses and subabool loppings. Maximum organic carbon was also observed with paddy straw, while it was recorded lowest with black polythene mulch even less than control.

Effect of planting system cum high density in aonla

An experiment was initiated with five planting system having different planting densities viz. (i) square system (100 plant/ha and 9 plants/plot) (ii) hedgerow system (166 plants/ha and 15 plants/plot) (iii) double hedge row system (222 plant/has and 20 plants per plot)(iv) cluster system (177 plants per ha and 16 plants/plot) (v) paired system (133 plant/ha. and 12 plant/plot).

Based on initial data, the results of study revealed that maximum plant (2.26 m) was recorded in double hedge row system followed by hedge row system, whereas minimum in cluster system of planting, while rootstock girth (15.42 cm.), scion girth (12.42 cm.) and plant spread (E-W=1.65m and N-S = 1.67 m) were recorded highest in square system of planting. However, all the treatments were found non significant in respect to vegetative parameters. On the basis of preliminary study, highest yield was recorded in double hedgerow system and lowest was recorded in square system. Highest fruit weight and fruit size were recorded in plants of square system, but differences among the treatments were non significant.

G.4 Crop regulation in Moringa and Inter cropping system under Semi arid condition.

Effect of Spacing on growth and yield of Annual Moringa (PKM-2) under semi arid condition:

Among the treatments the highest plant height (5.68 M) and stem dia (53.18 cm) was recorded of 5 × 5m spaced trees. The lowest time taken for flowering (115. days) was observed in 5 × 2.5 m spacing. The treatments are not significant for number of flowers panicle, number of panicle/tree. Higher number of pods per tree (248.5) and total yield per tree (58.31 kg) was observed in 5 × 5 m spacing which is almost two and half fold increase over control. Whereas, the highest yield per ha was recorded in treatment 5 × 2.5M (35.11 tonnes/ha.).

Studies on Pruning time on growth flowering and yield of Moringa var. PKM-2

The pruning was performed in monthly intervals and it was found that the treatment were significant. The highest plant height (5.60 M) was observed in the tree pruned in March. However, the maximum plants spread (12.18 m^2), minimum days for flowering (111 days), No. of panicles per tree(68), No. of pods per panicles(2.31) and the highest No. of pods per tree (240) was observed in the tree pruned in the month of December. The same treatment recorded the highest yield of 47.12 kg/tree.

The treatments are not significant to number of flowers per panicle and pod length. It was also observed that the tree pruned after December did not produced flower up to July.

Studies on production of cucurbits under moringa based cropping system through insitu water harvesting technique under rain fed condition

A field experiment was conducted comprising of four levels of FYM and four sizes of pits for *insitu* soil moisture conservation, the treatment 1.5 ×1.0×1.0m pit size with 60kg FYM was found to be the best for higher yield per pit (18.36, 36.13, 42.12 Kg) and yield per hectare (6.85, 14.25 and 15.43t/ha) in Ridge gourd, pumpkin and Moringa respectively. Though, the higher benefit cost ratio of 4.27 was observed in 0.5 ×0.5×0.5m pit with 10 Kg FYM, the highest net income of Rs.613485/- per ha was obtained in 1.5 ×1.0×1.0m pit size with 60kg FYM.

Studies on suitable crop combination under moringa based cropping system under rain fed condition

Among the different crop combinations of inter crops of vegetables tested in moringa, intercrops did not affect the productivity of base crop (Moringa). Almost stable yield of moringa in sole crop and inter crops suggested that the inter crops did not compete with the main crop. There was in the yield of inter crops as compared to their respective sole crops. The net income from inter cropping of Moringa + Pumpkin+ Cluster bean + cowpea (T13) gave maximum return of Rs. 78653/ha as compared to other crop combinations with benefit cost ratio of 1.51. The highest benefit cost ratio (2.42) was observed in pumpkin (sole crop) followed by Bhendi (2.13). However, the total net income was higher in inter cropping system.

Post Harvest Technology

Mission H. Post harvest handling and processing studies in arid zone horticultural crops

H.1 Post harvest handling and processing studies in arid zone horticultural crops

H.1.1 Studies on processing techniques in khejri (*Prosopis cineraria*)

An experiment was carried out in order to standardise optimum stage and suitable condition for dehydration of khejri pods. Based on earlier experiment results the present investigation was improved and modified. The tender pods are selected, sorted out and pods are subjected to two treatments and dried under seven different conditions. They are as follows:

Treatments:

1. Blanched in 2% salt solution for 5 minutes.
2. Unblanched pods (control).

Drying conditions:

1. Sun
2. Sun+pods covered with muslin cloth
3. Room condition
4. Tray drier
5. Under tree shade
6. Under shade net
7. In wooden drier

Observations were made on drying duration, recovery percent and nutrient analysis.

The experimental results revealed that the drying duration did not vary significantly among the treatments. However, there were much variation among different methods of drying. The pods dried in Sun took minimum hours and the maximum time taken in pods dried in room condition. The pods dried

under tree shade, shade net and in wooden drier did not vary significantly. The data on recovery percent revealed that there was not much variation among the methods and the treatments. However, the highest recovery percent was obtained in blanched pods dried in tray drier and lowest in pods dried under tree shade. Among unblanched pods the same trends follows (Table 36)

Table 36. Effect of drying methods on recovery percent and drying duration of khejri pods

Methods	Recovery %		Duration of drying (hour)	
	Blanched	Unblanched	Blanched	Unblanched
Sun	25.26	25.12	11	11
Sun + pods covered with muslin cloth	25.24	25.10	12	12
Room condition	25.18	25.18	46	46
Tray drier	25.29	25.20	14	14
Under tree shade	25.16	25.10	15	15
Under shade net	25.22	25.14	16	16
In wooden drier	25.24	25.19	16	16

The data on nutrient content reveals that the blanched pods were comparatively less in all nutrient to that of unblanched pods. The loss of nutrients while blanching may be one of the reason for lower nutrient content. The potassium content ranged from 1.45-1.65% in blanched pods and 1.47-1.66% in unblanched pods. Maximum potassium content was in pods dried under tree shade in each of blanched and unblanched pods.

Sodium content was maximum in blanched pods dried under tree shade (0.78%) and minimum in blanched pods dried in Sun covered with muslin cloth, while in case of unblanched pods the maximum was in tree shade (0.81) and minimum in pods dried in Sun covered with Muslin cloth and in wooden drier. The calcium content was maximum in pods dried under tray drier and minimum was in pods dried in wooden drier among blanched ones. In case of unblanched pods the maximum calcium content in pods dried under sun covered with muslin cloth and minimum in pods dried under tree shade (Table 37). The nitrogen content was maximum in blanched pods dried under tray dried and minimum in pods dried in wooden drier. In case of unblanched pods the nitrogen content was maximum in tray drier minimum in wooden drier.

H.1.2 Dehydration of Kachri (*Cucumis calosus*)

An experiment was carried out in order to standardize the dehydration techniques for *kachri*. The nutrient analysis revealed that the all nutrient content are comparatively on higher side in fruits dried along with peel to that of fruits dried without peel. The nutrient content was maximum in the tray drier for calcium, sodium and potassium and minimum in other two methods of drying (Table 38).

Table 37. Effect of treatment and drying methods on nutrient content of khejri pods

Methods	Potassium %		Sodium %		Calcium %		Nitrogen %	
	B	UB	B	UB	B	UB	B	UB
Sun	1.45	1.47	0.71	0.73	1.57	1.65	2.71	2.73
Sun + pods covered with muslin cloth	1.48	1.50	0.70	0.72	1.59	1.68	2.70	2.74
Room condition	1.51	1.51	0.72	0.73	1.59	1.63	2.72	2.72
Tray drier	1.65	1.66	0.78	0.81	1.60	1.65	2.75	2.76
Under tree shade	1.62	1.62	0.72	0.72	1.51	1.52	2.69	2.71
Under shade net	1.61	1.63	0.73	0.74	1.54	1.54	2.65	2.68
In wooden drier	1.62	1.64	0.71	0.72	1.52	1.53	2.62	2.65

B-Blanched, UB-Unblanched

Table 38. Nutrient contents in dehydrated kachri fruits in percent

Treatments/ Methods	Ca		Na		K	
	With peel	Without peel	With peel	Without peel	With peel	Without peel
Sun	1.372	1.215	0.215	0.198	4.034	3.915
Tray drier	1.382	1.216	0.225	0.218	4.234	4.115
Shade	1.372	1.215	0.215	0.198	4.134	3.915

Further improvement were made to the earlier methods and fruits were given 2% salt solution dip in order to improve the storage condition of dehydrated fruits and in two season summer and winter. The drying duration did not vary among the treatments. The minimum was in fruits dried in sun and maximum in pods dried under room shade (Table 39) during summer season. The recovery percent ranged from 11.83-12.02 in sun dried, 12.00-12.20 in tray drier and 12.00-12.20 in shade dried. The fruits with peel had higher recovery percent comparatively due to the retention of peel. However, the duration of drying was increased by 2 hours in sun during October-November and by 12 hours in shade. The recovery percent did not varied significantly (Table 40).

Table 39. Effect of drying method on duration and recovery of kachri fruits during summer

Methods/ Treatments	Duration of drying			Recovery percent		
	Sun	Tray Drier	Shade	Sun	Tray drier	Shade
Fruits with peel	10	14	36	12.02	12.20	12.20
Fruits with peel (Dip in 2% salt solution 1 Min.)	10	14	36	12.00	12.15	12.18
Fruits without peel	10	14	36	11.83	12.00	12.00
Fruits without peel (Dip in 2% salt solution)	10	14	36	11.83	12.00	12.00

Table 40. Effect of drying method on duration and recovery of kachri fruits during winter season (Oct.-Nov.)

Methods/ Treatments	Duration of drying			Recovery percent		
	Sun	Tray Drier	Shade	Sun	Tray drier	Shade
Fruits with peel	14	14	48	12.00	12.20	12.20
Fruits with peel (Dip in 2% salt solution 1 Min.)	14	14	48	12.00	02.15	12.18

Preparation of value added product from aonla

Aonla chyawanprash: Aonla is a well known fruit for its nutritive value (vitamin and minerals) and therapeutic properties from ancient times in aonla, which was considered wonder fruit for health. Therefore, an experiment was carried out to prepare Chyawanprash with different treatments. The treatment combination are given in Table 41.

The sensory evaluation was carried out and the score revealed that the treatment prepared with 1kg of pulp, 1.6 kg of missrie each 250g of ghee and ayurvedic ingredient: 5g of bhasma and 100g of honey, scored maximum. However, all the treatments were found acceptable for consumption (Table 42).

Aonla supari: Fully matured aonla fruits were selected, washed, the fruits are cut into small pieces. The pieces were blanched for five minutes. Mixed with powder of jeera, black pepper and cardamom. Dried in Sun and packed in polythene covers, which are used as mouth freshners and could replace other hamful tobacco products available in markets.

Table 41. Amount of ingredients for preparation of chyawanprash

Treatments	Pulp (kg.)	Sugar (Kg.)	Ghee (g)	Ayurvedic ingredients (g)	Bhasma (g)	Honey (g)
1.	1.0	2.0	200	200	7.5	200
2.	1.0	1.6*	100	250	5.0	100
3.	1.0	1.75	100	250	5.0	100
4.	1.0	1.6	100	250	5.0	100
5.	1.0	1.5	100	200	5.0	100

* Misarie is addred instead of sugar.

Table 42. Sensory evaluation of chyawanprash prepared with different treatments.

Treatments	Taste	Flavour	Colour	Overall acceptability
T1	7.12	6.38	7.74	7.08
T2	7.68	7.44	7.86	7.66
T3	7.52	7.24	7.43	7.44
T4	6.32	6.60	6.57	6.50
T5	6.24	6.36	6.96	6.52

At CHES, Godhra

H.2 Storage studies in Aonla and Ber

Aonla

1. Maturity standard in aonla cultivars

The specific gravity showed increasing trend in all the cultivars (Agra Bold, Anand-1, Anand-2) during development. TSS, total and reducing sugar content increased as the fruits reached towards maturity. Titratable acidity increased during initial period of fruit development then declined. In all the cultivars, vitamin C increased during development and became constant till the fruits attain physiological maturity. It may be concluded that fruits of Agra Bold matured by the last week of October while, Anand-1 and Anand-2 matured by middle of November under semi-arid ecosystem of Gujarat.

Effect of size grading on fruit quality and shelf life of aonla cv. Chakaiya

Fruits were divided in to 3 grades i.e. A, B and C and accordingly fruit quality attributes and shelf life were assessed during storage. A grade fruits recorded highest amount of vitamin C and it could fetch better price in the market due to better size, appearance and fruit quality.

Effect of pre- harvest treatments on storage life of aonla cv. NA-7

Pre harvest spray of Calcium nitrate 1.00 %, Calcium nitrate 1.50 %, Calcium nitrate 2.00 %, GA_3 50 ppm, GA_3 100 ppm, Silver nitrate 40 ppm, potassium sulphate 1.00%, potassium sulphate 2.00% and Bavistin 0.10 % were imposed on to the fruits 20 days before harvest. Data revealed that 1.5 and 2.0 % spray of calcium nitrate was found very effective to enhance shelf life (11 days) of fruits and retained maximum T.S.S, total sugar and vitamin C during storage of Aonla fruits cv. NA-7 under semi - arid ecosystem of Gujarat.

Effect of different packing containers on shelf life and fruit quality attributes of aonla cv. NA-7 during transportation

Different packing containers viz, gunny bag, fiber carton, Arhar basket, wooden crate and bamboo basket were used with polythene and newspaper as a liner during transportation of aonla fruits. Fiber carton and wooden crates with polythene or newspaper liner were found to be most suitable packing container during transportation of aonla fruits.

Effect of post harvest treatments on storage life of aonla

Polythene wrapping, GA_3 and calcium nitrate were used as post harvest treatments for

enhancing shelf life of NA-7 Chakaiya, Banarasi and Francis cultivars of aonla during storage. Studies revealed that fruits treated with 1.5% Calcium nitrate and kept in perforated polythene bag had maximum shelf life (NA-7 and Chakaiya 11 days, Francis and Banarasi 9 days) during storage.

Ber

Effect of pre harvest treatments on shelf life of ber cv. Gola and Goma Kirti

Pre harvest spray of Calcium nitrate 1.00 %, Calcium nitrate 1.50 %, Calcium nitrate 2.00 %, GA_3 50 ppm, GA_3 100 ppm, Silver nitrate 40 ppm, potassium sulphate 1.00%, potassium sulphate 2.00% and Bavistin 0.10 % were imposed on to the fruits 20 days before harvest. Data reveled that 1.5 and 2.0 % spray of Calcium Nitrate was found very effective to enhance shelf life (Goma Kirti-11 days and Gola 5 days) of fruits and retained maximum TSS , total sugar and vitamin C during storage under semi - arid ecosystem of Gujarat.

Studies on storage behaviour of ber cultivars

An experiment on storage behaviour of five cultivars of ber i.e. Gola, Goma Kirti, Umran, Seb and Mundia was conducted under ambient conditions. Umran recorded minimum PLW (23.00) on last day of storage (9^{th} day), which was closely followed by Goma Kirti (24.00%). Maximum PLW and spoilage loss were observed in variety Gola on 9^{th} day of storage (29.00%), T.S.S. and total sugar content were found to be maximum in Umran during storage, it was at par with Goma Kirti. In view of PLW, spoilage loss and fruit quality attributes, Gola and Goma Kirti can be stored under ambient condition up to 3 and 5 days respectively without causing economic loss due to spoilage.

Effect of post harvest treatments on shelf life of ber cultivars

Calcium nitrate and perforated polythene bag alone and in combinations were used for enhancing the shelf life of Gola and Goma Kirti cultivars of ber under ambient conditions. Goma Kirti and Gola fruits treated with calcium nitrate 1.5% and kept in perforated polythene bag showed least PLW and spoilage loss and retained maximum T.S.S., sugars and Vitamin C content up to last day of storage in both the cultivars. In view of the spoilage loss and fruit quality attributes Gola and Goma Kirti can be stored up to 5 and 9 days respectively without causing economic loss due to spoilage.

Plant Protection

Mission I. Integrated pest and disease management in arid zone horticultural crops

At CIAH, Bikaner

I.1 Studies on biological control of major diseases of arid zone fruits and vegetables

Management of ber powdery mildew using biocontrol agents.

In continuation of last year experiments, effective isolates of bioagents (CIAH-196 of *P.fluorescens* and CIAH-240 of *Trichoderma sp.*) were tested with different treatments combinations under orchard conditions. Fifty per cent which is less than the recommended dose of karathane (0.05%) and bioagents, 5% culture suspension of bioagnets were tested for their combined efficacy. Two sprays at monthly intervals were given in powdery mildew infected ber cultivars (cv.Gola and Umran). Each treatment was replicated twice and powdery mildew incidence was recorded from each tree. In general, powdery mildew intensity was more than 90% and therefore, the control efficacy was less than last year results. However, out of different treatments, 5% of *P.fluorescens* combined with half of the recommended dose of karathane resulted 59.5% per cent control efficacy followed by 57.25% in 10% of *P.fluorescens* alone. Other treatments were intermediate in control efficacy.

Management of Virus diseases of *mateera*

The effective isolates were mass multiplied in liquid media and talc based formulations was prepared for different treatments. Field and Pot culture studied were carried out for the management of virus diseases of *mateera* using prominent isolates viz., CIAH-151 and CIAH-240 of *Trichoderma* and CIAH-111, CIAH-196 and CIAH-311 of *P.fluorescens*. Liquid cultures of bacteria and *Trichoderma* were applied through different treatments combinations (Seed treatment, foliar spray, seed treatment + foliar spray). Efficacy of bioagents on seed germination and diseases incidence were recorded. Out of three isolates, CIAH-196 resulted better germination (92.1%) of seeds followed by 86.65% in isolate CIAH-311 as compared to 66.75% in untreated control (Table 43). The overall results revealed that none of the isolates was able to completely check the occurrence of diseases with special reference to virus diseases. However, isolate CIAH-111 showed 71.69 percent control efficacy when applied with seed treatment and foliar sprays (Fig 7).

Evaluation of ber germplasm and hybrids against major diseases

Powdery mildew is not a major problem under Bikaner conditions and therefore, the promising hybrids and selections are planted in endemic location ie., in the regional station (CHES, Godhra) and

will be evaluated. However, less incidence of fruit rots was observed in most of the commercial cultivars including selection and hybrid lines.

Table 43. Effect of Fluorescent Pseudomonads on seeds germination of mateera

Treatments	CIAH-111	CIAH-196	CIAH-311
Seed treatment	81.65	92.10	86.65
Foliar spray	64.15	66.63	65.35
ST + FS	81.00	89.50	87.65
Check	66.75	--	--
CD (p=0.05)	00.80	00.94	00.04

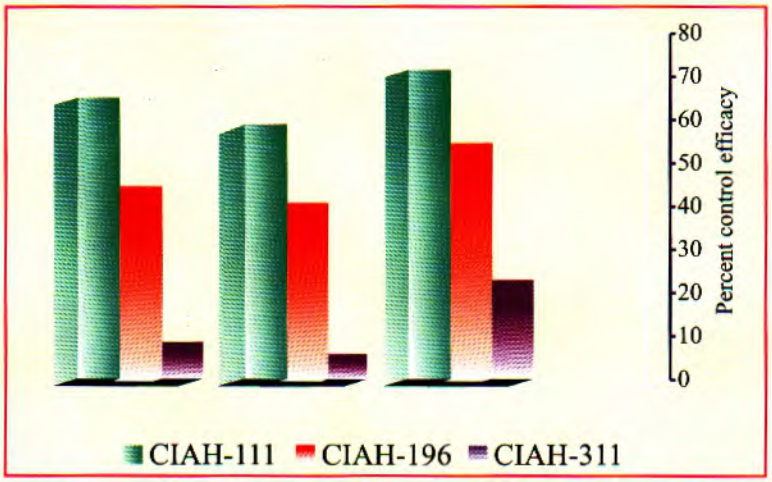


Fig. 7 Effect of Fluorescent Pseudomonads on percent control of virus diseases in *mateera*

Figure represents the Percent Disease Control of FPs isolates. CIAH-111 showed better efficacy followed by CIAH-196. None of the isolates could eliminate the disease incidences.

Evaluation of pomegranate hybrids against leaf and fruit spots

Advanced lines of pomegranate hybrids were evaluated against disease reactions. Majority of the lines were free from diseases. However, as similar to last year, some of the lines viz., AHPG/S4aL2-22, AHPG/S4bL3-14 and L314 were severely affected by *Culvularia* leaf spot (Plate 1). Cercospora leaf spot was also noticed in some of the lines. Alternative spray of 0.2% chlorothalonil and 0.2% mancozeb at weekly interval could suppress this leaf spot. Fruit spots due to *Alternaira alternata* and *Aspergillus* sp have been noticed in few lines. Most of the cracked fruits were severely colonized by saprophytic fungus.

Evaluation of arid vegetables germpalsm and hybrids against major diseases

Advanced lines of *mateera*, *Cucucmis*-AHC-2 and AHC-13, *tinda* and bottle gourd were

evaluated against major diseases. Out of these most of the *mateera* lines and *Cucumis* AHC-2 were susceptible to wilt and virus diseases (CYMV). Few plants expressed leaf curl virus and fungal leaf spots. Bottle gourd lines were highly susceptible to CYMV and moderate incidence with leaf spots. All lines of *tinda* showed susceptible reactions to CYMV. In subsequent evaluation, out of lines of *mateera*, (lines 1 to 18,122,123,140 and 150), brinjal, tomato, chilli, sponge gourd, beans and snap melon, *mateera* lines No.1 was free from diseases. Lines 10 and 11 recorded less than 5% incidence and line No.7, 135,140 and 150 were highly susceptible having (51.52 to 59.3%). Lines AHW-2, 30, 76,85,93 and 112 were free from diseases and lines 5,7 and 17 were from virus diseases. Most of the ridge gourd lines were highly susceptible to leaf curl and mosaic diseases. However, lines 4,7, and 8 were free from all diseases. Wilt incidence was more in chilli and 50% of the plants were affected. In brinjal, root rot incidence ranging from 23 to 26% was recorded. The pumpkin lines were severely affected by a new type of virus disease (Plate 2) and such symptoms have not been recorded in earlier years. In sanp melon, 1,2/3,3/5,/5/7,/9/3,10/15/19/40,20/46/22/50 and 30/65 were affected by leaf spots ranging between 16-33%. Out of all lines, No.6 was free from diseases. Out of 7 advanced lines of beans, AHPB-16 and AHPB-3 were free from diseases.

At CHES, Godhra

I.2 Studies on fungal and diseases of semi arid fruits (ber, pomegranate, aonla, anonna and phalsa)

I. Disease Management in powdery mildew of *ber*.

Epidemiological studies:

The disease first appeared in the second week of September and showed maximum progress during second to fourth week of October when it recorded PDI=64.21 as compared to 4.31 initially in first week of the same month. Its peak was recorded in the third week of November (PDI=75.21)

Management

Results of the control trials on varieties"Gola" and "Umran" using 11 treatments (including chemical, foliar fertilizer sprays, botanicals, biocontrol and organic treatments) showed that almost all treatments were superior over control. However, 3 Bayleton sprays (PDC 83.7 in "Gola" and 74.06 in Umran), 2 Bavistin sprays alternated with 2 Sulfex sprays (82.77 and 72.14), 2 Sulfex sprays alternated with 2 sprays of turmeric + Sodium bicarbonate + Hing (80.68,49.01), 3 Bavistin spray treatment (alone) (80.54,71.46), 4 Sulfex treatment (alone) (77.50,70.45), 2 Sulfex sprays alternated with 2 sprays of $KMnO_4$ (74.78,54.66), $MgSO_4$ (73.49,59.57), KH_2PO_4 (73.08,63.77), $KHCO_3$ (67.91,64.24) and salicylic acid 67.61 and 60.73) were more effective treatments and controlled the disease to appreciable level.

Biocontrol

The biocontrol agents developed at CIAH, Bikaner (Isolate No. CIAH-196 of *P. fluroscens* and CIAH-240 of *Trichoderma*) were also found to reduce the disease severity but for desired results its timely application was found essential. The detail results are presented separately.

II. Management of diseases of pomegranate

Mild infection of anthracnose on leaves and fruits was noticed (PDI=3.2) during August-September months. The disease was found reduced to nearly negligible level by one spray with Bavistin (0.1%), Blitox (0.3%) and Kavach (0.2%)(PDI ranging between 0.5 to 1.2 percent).

III. Management of diseases of aonla (including studies on post harvest technology project storage studies in ber and aonla.

In field, only mild (0.7%) disease incidence of phoma fruit rot, anthracnose and penicillium fruit rots were recorded. However, in laboratory (post harvest studies), the incidence was quite significant and after a week, about 50 per cent fruits showed rotting due to *Penicillium* sp. and *Aspergillus* sp. Application of pre harvest spray (about 1 week before harvesting) with Bavistin (0.1%), Blitox (0.3%), Kavach (0.2%), K_2SO_4(1.5%), $CaNO_3$ (0.2%), Urea+ KH_2PO_4(1%), KMnO4 (0.1%) and Bordeaux mixture (0.8%) recorded significant reduction (43-67%) in the disease incidence. Treatments with $AgNO_3$ (40 ppm), GA 100 ppm and dipping in 10 percent salt solution for 10 minutes also recorded reduced disease incidence. Injury was found essential for occurrence of both the diseases.

I.3 Investigations on fungal viral and mycoplasma diseases of solanaceous, cruciferous and bulbous vegetables.

Management of early blight of tomato:

Although almost all the ten treatments were significantly effective in reducing the disease severity, but the early blight was found to be best managed by 2 sprays with Blitox [(0.3%) (PDI=8.3)] and mancozeb [(0.2%) (PDI=6.7)] when compared to unsprayed plot (PDI=38.3). Ecofriendly organic cum-botanical preparations (Haldi + Hing+SBC) and Ranode (organic balls) were found effective (PDI = 9.8) in reducing the disease incidence. Spray and drenching applications of cow during slurry alongwith 1 g hing powder (PDI=11.3) and foliar spray of 1% solution of KH_2PO_4(PDI=14.2), salicylic acid (0.1%)(17.3) and 0.5% sodium bicarbonate (13.5) also helped in reducing the severity. Application of biocontrol (*Trichoderma harzianum*) fungi in soil (10^5 cfu in rhizosphere) followed by one spray on plant surface with mancozeb reduced the severity to almost half (PDI=19.7). Cultural control including clean cultivation, removal of lower infected leaves, summer ploughing, mulching, staking etc. also contributed significantly in disease reduction (PDI=24.2).

It is concluded that application of Ranode organic balls, hing +turmeric +SBC, (sodium bicarbonate(0.5%) and KH_2PO_4(1%) sprays may be alternated with fungicides to reduce the severity of the early blight of tomato.

Management of leaf curl of tomato

Putting yellow sticky traps and planting of five barrier rows of maize, jowar and sunn hamp, six week ahead of transplanting of tomato, prevented the infection of TLCV upto about 85 days of transplanting. Marigold was relatively less effective, probably because of its slow growth. Cowdung slurry and salicylic acid sprays also showed reduced disease incidence as recorded after 90 d.a.t. Cow milk sprays (50%) were also found effective in reducing disease severity and delayed the appearance of the disease upto 80 days. The disease reduction in insecticidal sprays was maximum (upto 100 d.a.t.). In untreated control the disease appeared after 45 days and its spread and intensity was maximum (48%) during November.

Integrated Disease management of anthracnose of Chilli in variety Pusa Jwala and of powdery mildew in variety G-4

The anthracnose (ripe fruit rot) of chillies was found to be important problem. Blitox (0.3%) and Dithane M-45 (0.2%) sprays twice during September and October reduced the disease severity (expressed as % fruit rotted) from 17.3 percent in control to 1.7 and 2.1 respectively in the above treatments.

Powdery mildew

The powdery mildew was found to be managed by 3 sprays of 1% KH_2PO_4 which reduced the disease intensity (PDI) from 69.33 in control to 14.77 in treatment. The disease intensity also was found to be reduced by spray with $MgSO_4$(0.5%) + $KHCO_3$(1%)(PDI 20.58), K_2HPO_4(PDI=20.42) $NaHCO_3$ (16.33). The effect of KH_2PO_4(+ KOH) was found to last upto 2 weeks and the results were consistent in the treatment.

Integrated disease control of post-emergence damping-off in chilli and tomato

The diseases was found to be managed by soil-solarization, fumigation with 1% formal in, seed treatment with Ridomil Mz (0.25%), Captaf (0.3%) and Blitox and also by drenching with the same fungicides. The extent of disease control was nearly 80-90 per cent.

Studies on the diseases of brinjal:

Corynespora casiicola leaf spot disease was seriously infecting the crop. Mancozeb (0.2%) and Blitox (0.3%) sprays managed the disease effectively. Little leaf was found to be managed by barrier crops of sunn hemp, maize and jowar, phytosanitary measures and one spray during October.

The barrier crops were also found effective in managing other systemic viral diseases like TLCV of tomato, YVMV of Okra and leaf curl of chillies.

Studies on other diseases problems

Following other diseases were identified during the year:

i) Major fruit rot causing organisms in tomato were *Corynespora cassiicola, Curvuaria lunata, Alternaria solani, A tenuis, A.alternata* and *Fusarium* sp.

ii) Brinjal leaf spots due to *Corynespora cassiicola*.

iii) Crotalaria juncea (barrier crop) was found infected with phyllody and attracted a large number of leafhoppers(*Orosius albicintus*).

iv) Okra powdery mildew colonies were found heavily infected with *Ampelomyces quisqualis*, which was cultured on PDA.

1.4 Pest management in Ber, Pomegranate, Aonla and Sapota.

Control of fruit fly, *Carpomyia vesuviana* Costa and fruit borer. *Meridarchis scyrodes* in *ber*

Applications of either fenvalerate (0.005%), or deltamethrin (0.0015%), at 21 day interval followed by two applications of NSKE (5.0%) at 10 day interval was found to be effective in reducing the incidence of both fruit fly and fruit borer infesting ber cv. Gola and Umran. Another treatment comprising of half dose of fenvalerate (0.0025%) with half dose of NSKE (2.5%) proved equally effective in controlling these pests.

Control of thrips *Scirtothrips dorsalis* Hood and anar butterfly, *Virachola isocrates* in pomegranate cv. Ganesh.

Application of two sprays of either dimethoate (0.05%) or acephate (0.05%) at 15 days interval followed by two application of NSKE (5.0%) at 7 days interval proved effective in suppressing the population of thrips.

Control of borer complex in borer in Aonla cv.NA-7.

(i)*Virachola isocrates*
***(ii) Meridanchis* spp.**

Periodical samples collected from the field revealed the incidence of borer complex to the tune of 35.0 %. However the incidence of these pests was drastically reduced by the application of either fenvalerate (0.005%), or deltamethrin (0.0015%).

I.5 Pest management in Chilli and Brinjal:

Control of chilli thrips Scritothrips dorsalis Hood in chilli cv.pusa jwala and Bhagya Laxmi (G-4)

Chilli leaf curl transmitted by thrips was effectively managed by the application of either dimethoate (0.05%), or acephate (0.05%) at fortnightly interval followed by two applications of NSKE (5.0%) at weekly interval.

Control of Jassid *Amrasca biguttula biguttula*, Ishida and fruit borer *Leucinodes orbonalis* Guen in brinjal cv. Pusa Kranti.

Applications of either fenvalerate (0.005%), or acephate (0.05%), at triweekly interval commencing from 21 days after transplanting followed by two applications of NSKE (5.0%) at 10 day interval significantly suppressed the population of jassid in the field and the incidence of fruit borer was also found drastically reduced.

Plant production

Mission K: Production of planting materials

At CIAH, Bikaner

Establishment of Field Repository

At CIAH, Bikaner, 2-hectare area has been developed as "Field Repository" by planting different arid fruit types, which will also serve as conservatory for demonstration of fruit types suitable under arid ecosystem. So far, 60 varieties/strains of different fruit trees accommodating 21 genera have been collected from different places in India and abroad. The major fruit trees are ber, bael, aonla, pomegranate, khejri, *Citrus* species, mulberry, phalsa, karonda, pilu, lasoda etc.

Introduction of plants

Before planting in the field, proper acclimatization and hardening of new introductions are very essential. For the purpose, four growing structures have been developed. Fine nozzle sprinkler system has been installed for irrigation purpose. These structures are also being utilized for multiplication of fruits, vegetables and ornamental plants. As new introduction during 2002-2003, some plants and seeds of bael have been introduced in to nursery for further planting in bael block. Bitter type of Aloe was also collected from the Gujarat. The seeds of Jatropha was collectd from S.K.Nagar (Gujarat) and sown in the nursery. The cuttings of pomegranate brought from Guiana was planted in the mist unit but failed to survive. The cuttings of fig, tamarind, grape and pomegranate also introduced from Niger but did not survive.The seeds of two *Ziziphus* species i.e. Z.*oenoplea* and Z. *xylopyra* were introduced from Jhansi and sown in the nursery for experimental purpose

Establishment of Mother Block

One ha area has been developed as mother block. Three commercial fruit types namely ber, aonla and pomegranate have been accommodated in the mother block. This will serve as source of scion shoots for commercial multiplication of these fruit trees. Three rows of each fruit were planted at closer spacing. The fruit types, spacing and their promising varieties are given in table 44.

Table 44. Fruit types, spacing and their promising varieties planted in mother block

Fruit type	Spacing (m)	Promising variety
Ber (Ziziphus mauritiana)	6 x 4	Gola, Umran, Seb, Goma Kirti, Banarasi Karaka
Aonla (*Emblica officinalis*)	6 x 6	Neelam, Amrit, Chakaiya
Pomegranate (*Punica granatum*)	4 x 2	Jalore Seedless, Ganesh, G 137

Evaluation of fruit trees

To generate first hand information about their performance, the fruit plants planted in nursery

are also under evaluation The management practices were similar for all the varieties of a particular fruit type. The irrigation, fertilization, intercultural operations, training and pruning etc. were based on the recommendations already available. The data on vegetative vigour and fruit yield have been presented in table 45.

Table 45. Vegetative vigour and fruit yield of some arid fruits planted in the nursery.

Fruit type/ cultivar	Yr.of plantation	Plant height (m)	Crown spread (m^2)	Fruit yield (kg/ tree)
Bael				
Pant Aparna	August, 1998	3.05	13.00	09.50
Pant Sujata	August, 1997	4.30	14.50	10.50
Pant Swarna	August, 1997	5.55	16.85	--
Pant Shivani	August, 1997	5.40	13.45	05.00
Pant Urvashi	August, 1997	5.35	19.25	26.00
NB 5	August, 1997	3.45	10.05	30.50
NB 7	August, 1997	5.50	11.00	04.00
NB 9	August, 1997	2.95	07.00	20.50
Dhara Road	Sept. 1999	3.35	09.00	-
Ber				
Kaithali	Sept., 1998	3.85	05.25	12.50
Umran	Sept., 1998	3.45	04.00	16.25
Seb	Sept., 1998	3.40	04.75	13.00
Gola	Sept., 1998	3.30	05.75	23.00
Goma Kirti	Aug., 1999	2.25	03.00	12.00
Citrus				
Sweetorange: Mosambi	August, 1997	3.85	10.25	20.50
Mandarin: Kinnow	August, 1997	3.40	09.00	--
Malta	August, 1997	2.55	05.00	--
Grapefruit:Marsh Seedles	August, 1997	3.05	08.25	--
Red Blush	August, 1997	3.00	07.00	15.50
Lemon: Pant 1	August, 1997	2.85	10.50	04.00
Guava				
Allahabad Safeda	Sept., 1997	3.65	08.00	05.50
L 49	Sept., 1997	2.40	04.00	07.50
Karonda				
KS 1	July, 1997	2.60	03.00	03.00
KS 2	July, 1997	2.85	02.25	06.50
KS 3	July, 1997	2.00	02.75	02.00
KS 4	July, 1997	1.90	03.00	05.25
KS 5	July, 1998	1.05	01.10	01.50
*Lasoda				
LS 1	July, 1997	4.20	03.00	--
LS 2	July, 1997	5.95	47.00	165.00
LS 3	July, 1997	6.35	42.00	196.00
Pomegranate				
Ganesh	July, 1997	2.70	01.75	--**
G 137	July, 1997	3.00	01.25	--
Jalore Seedless		2.00	01.50	--
Mulberry	July, 1998	3.65	07.75	08.75

*Tender fruits for vegetable purpose ** Shoots were taken for multiplication

Multiplication of experimental materials

For experimental purpose, the plants were multiplied in nursery, maintained, hardened and handed over to the concern scientist for plantation at desired site (Table 46).

Table 46. Plants multiplied for experimental use

Plant type	Technique of multiplication	Quantity	Purpose
Ber	Budding	150	For plantation in mother block (100) For aonla based experiment (20)
	By seeds	70	For ber based agroforestry block (50) For aonla based cropping system block(20)
Aonla	Budding	20	For mother block(10) For aonla based cropping system (10)
	By seeds	110	For aonla germplasm block (70) For aonla based cropping system (40)
Pomegranate	By cutting	200	For mother block (150) For pomegranate block (50)
Bael	By seeds	100	For bael block (100) For aonla based AFS (40)
	By budding	24	For aonla based cropping systems (15) For ber based cropping system (9)
Date palm	By seeds	150	For datepalm block(150)
Ker	By cutting	80	---
Gonda	By seeds	20	For nursery (10) For ber based agroforestry block (10)
Phalsa	By seeds	150	For nursery unit (100) For ber based agroforestry (50)

Multiplication of ornamental plants

The following ornamental plants were multiplied for beautification of campus, nursery area and farm complex (Table 47).

Table 47. Ornamental plants multiplied

Plant type	Propagation method	No. of plants
Bougainvillea	Cutting	65
Mehndi	Cutting	150
Clerodendran enormi	Cutting	50
Jasmine	Cutting	35
Chrysanthimum	Sucker/ cutting	50
Pot plants	Sucker	100
Seasonal Flowers	Seeds	2000

Commercial propagation

The fruit trees of commercial significance like; ber, aonla and pomegranate have been multiplied through vegetative means for distribution of true-to-type of planting materials among farmers and also for experimental purpose (Table 48). As a source of revenue generation, these planting materials were sold to the farmers. Besides these, the seed produced by the Institute is illustrated in Table 49.

Table 48. Production of planting materials (2003)

Crop	Plant produced at CIAH, Bikaner	Crop	Plant produced at CHES, Godhra
Ber	2000	Ber	165
Aonla	250	Aonla	986
Pomegranate	700	Pomegranate	354
Khejri	300	Mango	219
Bael	150	Guava	224
Lasoda	1200	Papaya	53
Indian Aloe	1512	Sitaphal	115
Phalsa	1000	Lime	239
		Gulmahor	42
		Bougainvillea	63
		Croton	10
		Other plant	354

Table 49. Seed production during 2003-2004

Crop	Seed production at CIAH, Bikaner in kg	Crop	Seed production at CHES, Godhra
Mateera (AHW-65)	50.0	Okra (Arka Anamika)	35.0 kg
Kachri (AHK-119)	43.0	Clusterbean (Goma Manjri)	60.0 kg
Snapmelon (AHS10 & AHS-82)	52.2	Other vegetable seeds	108 kg
Kakdi (AHC-13)	05.0	Chilli	19700 seedlings
Moringa (AHMO-1)	03.0	Brinjal	2300 seedlings
Cluster bean (AHG-13)	58.0	Tomato	650 seedlings

Total revenue realized Rs. 906.

Agricultural extension

At CIAH, Bikaner

A. Extension research activities

A study on horticultural development in IGNP area of Bikaner district

The survey was conducted in IGNP (Indira Gandhi Nahar Project) area of Bikaner district (Rajathan) and the data/information collected during the survey revealed that during kharif season 22% farmers grow brinjal, bottlegourd, roundmelon; 16.5% farmers grow ber, aonla, pomegranate; 34% farmers grow mateera, snapmelon, kachari; Indian aloe on their fields as sole crops in irrigated condition. In irrigated condition, farmers also grow clusterbean/mateera/snapmelon/kachari/India aloe/groundnut/brinjal/bottle gourd, etc. as intercrop in ber, aonla and pomegranate orchards during kharif season.

During Rabi season and irrigated conditions, cumin/pea/green fodder/mustard/cauliflower/ cabbage/wheat/gram, etc. is grown by 25.5% farmers as intercrop in ber and aonla/pomegranate orchards.

The mixed cropping system is an important conventional cropping system which is practiced by majority of the farmers in rainfed areas during kharif season. The major component crops of the mixed cropping system are : pearlmillet, seasemum, clusterbean, groundnut, cowpea, mothbean, mateera, snapmelon, kachari, roundmelon, bottlegourd, ridgegourd, etc. which are grown in different combinations. Some of the farmers have adopted improved varieties of ber (seo, gola, umran), aonla (NA-7, NA-6, Chakaiya), Mateera (AHW-65, AHW-19), Snapmelon (AHS-10, AHS-82) and kachari (AHK-119, AHK-200). They also grow local/deshi varieties of the above crops.

However, majority of the farmers neither know nor grow improved varieties of arid horticultural crops. They also do not follow right time and proper method of sowing, proper methods and frequency of irrigation, fertilizers and pesticides, etc.

An assessment of arid horticultural status in Bikaner district of Rajasthan.

The data/information collected during bench mark survey conducted in Bikaenr district (Rajasthan), revealed that 32, 14.50, 16.20, 41.64, 44.35 and 28.0 epr cent farmers of the surveying area, grow (including both improved and local varieties) ber, aonla, pomegranate, mateera, snapmelon and kachari, respectively on their fields during different seasons of the year. 24 per cent farmers grow brinjal, bottlegourd, ridge gourd, roundmelon, chilli, Indian aloe etc. during kharif season, 32 per cent

farmers grow brinjal, cauliflower, cabbage, spinach, tomato, carrot, radish, fenugreek (green leaves), etc. at small scale and 26.35 per cent farmers grow cumin and fenugreed (seeds) at large scale during the Rabi season under irrigated conditions. Most of the farmers grow local/deshi varieties of the above crops. They purchase the seeds from local markets/fallow farmers/friends and grow them on their fields.

The farmers are very eager to grow lime/lemon, mosambi, kinnow, mandarin, guava etc. and some of them have developed good orchards of lemon/lime, mosambi, kinnow etc. The farmers purchase planting material of the above fruit crops from different sources/places of the Rajasthan/other states of the country and trying to develop orchards of these fruit crops on their fields.

It was also found that more than 56.8 per cent mateera, snapmelon and kachari growers use broadcasting method of sowing while cent per cent ber aonla and pomegranate growers use square system of plantation, more than 60 per cent farmers use sprinkler irrigation system in growing vegetable crops while rest of them use channel or ferrow system of irrigation. Only 18-28 per cent farmers use drip irrigation system in growing fruit crops. DAP fertilizers is used comparatively at lower scale. However, most of the farmers use nitrogenous fertilizers and organic manure in their growing horticultural crops.

Some of the ITKs related to plant protection measures, termite control, seed storage, improving soil fertility, preparation of PHT products, irrigation and water/moisture management, improving quality/growth and production of arid horticultural crops were also collected and documented.

During the survey, the constraints which inhibit the progress of arid horticulture were also evaluated. According to the farmers, the major constraints which restrain the horticultural development in IGNP area/Bikaner district of Rajasthan are: Poor and erractic rain fall, scarcity of water, very deep and salty ground water, frequent drought, poor soil conditions, lack of location specific suitable technologies, lack of technological knowledge amongst the farmers, very high/low temperature, shifting of sand/sand dunes during summer season, no effective plant protection measures, non availability of desired quantity and improved quality of seed and planting material, lack of reliable sources of inputs at local level with reasonable cost, faith in with traditional cropping system and cultural practices, lack of local markets to sell the produces, no security against the crop failure, attack of wild animals/birds/pests/diseases, distress sell of the horticultural produces, lack of loan/credit and subsidy system to purchase inputs, etc.

B. Extension activities

Farmers visit to the institute's farm

About 679 farmers and B.Sc. (Ag.) students from different district of Rajasthan and other states of the country were visited to the Institute's farm/experimental blocks/research laboratories to show the

improved arid horticultural technologies and ongoing research programmers of the institute. The major purpose of such visits of farmers/students was to import the knowledge about the innovative arid horticultural technologies and popularize the same amongst them.

Visit of scientific groups/personalities of the Institute

The various scientific groups/high dignitaries from SAU's, ICAR research center, NGOs, etc. come to the Institute which were visited to the Institute's research laboratories & experimental block/farm and required information, particularly, pertaining to extension activities of the Institute were provided to them.

Visit of farmer's field

The various visits were made to farmer's field to know their problems related to production of arid horticultural crops. The problems, felt need, and resources of the farmers were analysed and they were guided to overcome their problems and bottlenecks in arid horticultural crop production. These farmers were also guided through telephonic talk to eradicate their problems with respect to growing horticultural crops.

Organization of training programmes

A training programme was organized for state extension functionaries/agricultural supervisiors on "Innovative techniques of arid horticulture" dated 21.08.2003. Another training programme was organized for the farmers on the occasion of "Aonla Day" celebration (09.12.2003) in which farmers were trained aobut innovative package of practices of aonla cultivation and preparation of post harvest aonla products like aonla "Murabba" candy, shreds, Chawanprash, etc.

Popularization of arid horticultural technologies

The arid horticultural technologies like improved varieties of mateera, kachari, snapmelon, aonla, ber, pomegranate, lasora and their cultural practices were popularized amongst the farmers/ clients through personal contact, demonstration, exhibition, mass media, news papers, press conferencing, etc.

The functional linkage were also maintained with KVKs, Directorate of Extension ant ATIC of RAU, Bikaner; state Gvot. Dept of agriculture/horticulture and NGOs for popularizing and disseminating of CIAH technologies and arid horticultural development.

Organization of a press conference

The institute organized a conference of press-media person on 7.2.2004 with the purpose that they may get acquaint with innovative arid horticultural technologies and they will help in transfer of the same to the farmer's fields through news paper and other means of mass media.

Participation in farmer's fairs

The Institute participated in a district level "farmer's fair" organized by state Govt. department of extension on 10.12.2003. An exhibition of arid horticultural technologies was arranged by the Institute in this fair and vegetable seeds/planting material was provided to several farmers during the fair. The exhibition/stall arrangement was highly appreciated by the visiting farmers and viewers.

The Institute also participated in State level farmers fair organized by RAU, Bikaner on 24.2.2004. An exhibition of arid horticultural technologies was arranged by the Institute in this fair also and provided vegetable seeds/planting materials to the farmers. The exhibition of our Institute was considered as one of the best exhibition amongst all exhibition arranged by participating Governmental and non-Governmental agencies/organization and it was awarded with second prize.

Opening of sale counter of the Institute

The Institute opened/started a sale counter at the Institute on 30.12.2003 to provide the vegetable seeds; planting material of fruit crops, fruits, vegetables and post harvest products of the Institute to the farmers and other consumers. The major purpose of establishment of this sale center is to provide the improved seeds of arid vegetables, planting material of arid fruit crops and their products at reseanable cost and on time to the arid farmers/population.

At CHES, Godhra

A. Extension Research activities

Strategies for adoption of integrated horticultural technologies

Strategies for horticulture development in India

A strategy for development of horticulture in India was proposed. The state departments of horticulture have to be strengthened by improving the manpower, qualitatively by capacity building and quantitatively by recruiting more staff. New insurance policies specially designed for individual small and marginal farmers, covering all risks should be launched. The credit organizations like banks, cooperative societies should provide loaning facilities at low interest to venture in horticulture. The ways of harvesting rainwater, judicious use of ground water should be explored. Irrigation projects and watershed development projects should be geared up. Water use policy should be streamlined. All the organizations involved in horticulture *viz.* state department of horticulture, research institutes, input agencies, credit organizations, insurance corporations, marketing cooperatives should be networked and all the services of these organizations should be reached to the farmers through a 'single window'. This window should take care of his all requirements including technology, input, credit, and market.

B. Extension Activities

Farm visit

During 2003-2004, 812 farmers, 214 farmwomen, 58 extension functionaries, 5 scientists, 98 students, and 4 VIPs visited the station.

RAWE

B.A.Collge of Agriculture, Gujarat Agricultural University, Anand Campus has started Rural Agricultural Work Experience (RAWE) programme in its B.Sc. (Agri.) degree programme. Under this, CHES, Vejalpur has been selected as one of the ICAR stations to impart practical oriented training programme to seventh semester B.Sc. (Agri.) students. Accordingly, the station imparted one day exposure training to these students. The details of the training programme is given below;

Training coordinator: V.Lenin, Scientist (Agricultural Extension)

Sl. No.	Name of the trainer with designation	Date of training	No. of students trained
1	V.Lenin, Scientist (Agricultural Extension)	18.09.2003	10
2	Dr.S.S.Hiwale, Sr. Scientist (Hort.)	24.09.2003	12
3	Dr.H.K.Joshi, Scientist (SG) (Pl. Path.)	30.09.2003	12
4	Dr.A.K.Singh, Scientist (Hort.) and S.Raja, Scientist (Veg.)	06.10.2003	13
5	Dr.Sanjay Singh, Sr. Scientist (Hort.)	11.10.2003	13

Externally funded projects

A. National Agricultural Technology Project

Project Collection, evaluation and maintenance of arid horticultural crops under NATP on sustainable management of plant bio-diversity

(B.B.Vashishtha, D.K.Samadia and R.C. Ashwani)

Project at a Glance:

Mission: Sustainable management of plant bio-diversity, "Collection, evaluation and maintenance of arid horticultural crops

Objectives: To survey, collect, evaluate, characterize, multiply and maintain the plant bio-diversity of arid zone fruits and vegetables.

Lead centre: National Bureau of Plant Genetic Resources, New Delhi 110 012

Cooperating center: Central Institute for Arid Horticulture (ICAR), Bikaner (Rajasthan)

Principal Investigator: Dr. D. K. Samadia, Senior Scientist (Hort.), CIAH

Associated Scientists: Drs. R. S. Singh, Anil Kr. Shukla and Arun Kr. Shukla

Duration of project: July 1999 to December 2004

Total Budget allocation: Rs 18,91,850=00.

Central Institute for Arid Horticulture (CIAH), Bikaner is co-operating centre under NATP on sustainable management of plant bio-diversity for collection, evaluation and maintenance of arid horticultural crops and is also one of the identified National Active Germplasm Site (NAGS) for maintenance, multiplication and conservation of horticultural crops in arid region. Besides this, the institute mandate is to utilize genetic diversity in improvement programme and development of superior genotypes for high quality production under stressed environment. In Pre-NATP era (1994-1999), under mission mode approach of NRCAH (now CIAH), this centre has made excellent growth in building up of plant genetic resources and its utilization particularly in arid zone fruits and vegetables. As a result of massive germplasm collection and augmentation programme (1994 to 1999), this centre has developed *ex situ* field repository of *ber* (300), pomegranate (150), date palm (47), *aonla* (19), *bael* (5) and *lasora* (2) where as in vegetable a collection of 193 in watermelon (*mateera*), 558 of *kachri*, 90 of snapmelon and 132 of chilli and from July 1999 this work is continuing under NATP subproject.

From July 1999 to March 2004, a series of explorations and trips were undertaken for surveys, identification and collection of horticultural plant bio-diversity from parts of arid, semi-arid and sub humid regions of Rajasthan and Gujarat (Table 50) and resulted in identification of elite trees in arid fruits and a good number of collections have been made in *ber, Ziziphus mauritina* (33), *aonla, Emblica officinalis* (26), *bael, Aegle marmeolus* (7), *ker, Capparis* decidua (64), *lasora, Cordia myxa* (65), date palm, *Phoenix dactylifera* (46), muskmelon, *Cucumis melo* (55), bottlegourd, *Lagineria siceraria* (18), spongegourd, *Luffa cylindrica* (15), ridgegourd, *Luffa acutangula* (19) and chilli, *Capsicum annuum* (52) at CIAH, Bikaner. Besides, evaluation of a large number of germplasm in vegetable crops either collected by the CIAH or received from co-operating centers of arid region under NATP on plant bio-diversity for characterization of germplasm and multiplication of seeds in sufficient quantities for the conservation in National Gene Bank at NBPGR, New Delhi (Table 51). These comprised of watermelon/mateera (64), roundmelon (14), muskmelon (55), snapmelon (65), kachri (63), kakdi (15), bottlegourd (20), bittergourd (4), ridgegourd (20), spongegourd (15), chilli (70), brinjal (25), tomato (14), Indian bean (30) and sword bean (01). On evaluation and characterization under extremes of arid conditions over the period from 2000 to 2004 at Bikaner, these vegetable crop germplasm accessions exhibited a wide range of variability for agro-morphological traits, flowering and fruiting behavior, maturity, yield and quality contributing characters. For detailed characterization and documentation, important attributes on plant phenology and growth behavior, foliage colour, yield potential and fruit quality, fruit shape, size, colour, texture and seed content and seed characters, and response to biotic and abiotic stresses were recorded. The evaluated vegetable crop germplasm have been categorized and promising genotypes possessing desirable traits for fruit quality, maturity and yield contributing parameters under extremes of arid conditions have been identified.

Table 50. Status of explorations for the survey and collection of germplasm under NATP

Crop	Areas explored	ACC.	Associated scientist for the collections
Ber	i) Parts of Rajasthan and Gujarat	15	Anil Kumar Shukla and DK Samadia
	ii) Parts of Andaman's	04	BB Vashishtha and DB Singh
	iii) Parts of Uttranchal	14	Anil Kumar Shukla withNBPGR: Bhowali
Aonla	i) Parts of Rajasthan and Gujarat	05	Anil Kumar Shukla and DK Samadia
	ii) Parts of Himachal Pradesh	12	Arun Kumar Shukla
	iii) Parts of Rajasthan	09	Arun Kumar Shukla
Ker	i) Arid and semi-arid areas of Rajasthan	64	DK Samadia
Lasora	i) Arid and semi-arid areas of Rajasthan	65	DK Samadia
Bael	i) Parts of Andamans	07	BB Vashishtha and DB Singh
Date palm	i) Kachchh region of Gujarat	46	RS Singh and DK Samadia
Muskmelon	Arid, semi-arid and sub-humid areas of Rajasthan	55	DK Samadia
Chilli	Arid, semi-arid and sub-humid areas of Rajasthan and Gujarat	52	DK Samadia
Gourd cucurbits	Arid, semi-arid and sub-humid areas of Rajasthan and Gujarat	60	DK Samadia

Table 51. Status of germplasm deposition for conservation in NGB at NBPGR by CIAH

Crop	Year	Acc.	Status and Source of material
Muskmelon	2001	55	NATP CIAH Evaluated material
Kachri	2002	510	Pre-NATP CIAH germplasm $ Regeneration
Chilli	2002	132	Pre-NATP CIAH Evaluated material
Indian bean	2002	10	CIAH Characterized material
Watermelon	2002	13	Characterized at CIAH (NATP material NBPGR, RS Jodhpur)
Roundmelon	2002	14	Characterized at CIAH (NATP material of NBPGR, RS Jodhpur)
Longmelon	2002	15	Characterized at CIAH (NATP material NBPGR, RS Jodhpur)
Chilli	2003	70	Characterized at CIAH (NATP material of CIAH & GAU)
Tomato	2003	14	Characterized at CIAH (NATP material of GAU, Vejapur)
Brinjal	2003	25	Characterized at CIAH (NATP material of CIAH & GAU)
Indian bean	2003	20	Characterized at CIAH (NATP material of GAU, Vejapur)
Mateera	2004	36	Pre NATP CIAH Characterized material $ Regeneration
Snapmelon	2004	37	Pre NATP CIAH Characterized material $ Regenaration
Bottlegourd	2004	20	NATP CIAH characterized material
Ridgegourd	2004	20	NATP CIAH characterized material
Spongegourd	2004	15	NATP CIAH characterized material
Bittergourd	2004	03	NATP CIAH characterized material
Sword bean	2004	01	NATP CIAH characterized material

Progress in Research (2003-2004)

A. Explorations for the survey and collection of germplasm

a) Collection of aonla from parts of Rajasthan (Dr. Arun Kumar Shukla)

An exploration for the survey, identification and collection of elite types in *aonla* was under taken during December 2002 in the semi arid areas of Rajasthan covering Jaipur and Ajmer districts, where seedling *aonla* (*Emblica officinalis*) in natural form. In this trip, only bud sticks of elite *aonla* trees were collected in July 2003 and top worked on existing seedlings rootstocks in *aonla* field repository for evaluation and characterization at CIAH, Bikaner.

B. Evaluation, characterization and conservation of fruit crop germplasm

a) *Ber* (Anil Kumar Shukla)

Two explorations for the identification and collection of ber germplasm were conducted during

2000 and 2001 from parts of Rajasthan and Gujarat, and The Andamans, respectively. During the year 2003 an exploration in the villages of the district Nainital, Udhamsingh Nagar, Haridwar, Pauri and Dehradun was under taken in collaboration with NBPGR, Regional station, Bhowali (Uttranchal). As results of three explorations under NATP on plant bio-diversity, a total 33 genotypes of ber (Ziziphus spp) were collected and are being maintained in the National field repository of *Ziziphus* at CIAH, Bikaner. After establishment in the field gene bank, during the year 2003-04 observations on plant growth, flowering and fruiting behaviors were recorded to evaluate the collected germplasm under hot arid environment. A wide rang of variations have been recorded for plant phenological and flowering characters. The wide range of variation was recorded for plant height (2.0 5.75 m), plant canopy spread (2.5 × 2.0 to 5.5 × 5.0 m), main scion-stem diameter (3.5 7.5 cm) and leaf size (2.1 × 2.0 to 9.2 ×6.4 cm). Further, during the reported period the highest fruit yield (25 kg/plant) was obtained in accession AKS/ DKS/ NRCAH/ 40 after three year. In this genotype the average fruit weight was 24 g and fruit size was 4.3× 3.2 cm. All the genotypes are performing well and characterization is in progress (Table 52).

Table 52. Status of germplasm of arid zone fruit crops - Collection, evaluation, characterization and conservation under NATP on plant bio-diversity at CIAH, Bikaner

Crop	Accessions Collected at CIAH	Associated Scientist for collections	Associated Scientist for characterization	Remarks
Ber	33	Anil Kr. Shukla BB Vahsihtha DK Samadia	Anil Kr. Shukla	Evaluation and characterization work is under progress along with the pre NATP material at CIAH, Bikaner as an institutional programme on plant genetic resources management in arid zone horticultural crops. The crop associated scientist will characterized the germplasm colleted under NATP for the maintenance and conservation in the field repository at CIAH, Bikaner (Rajasthan).
Aonla	26	Arun Kr. Shukla DK Samadia Arun Kr. Shukla	Anil Kr. Shukla	
Ker	64	DK Samadia	RS Singh	
Lasora	64	DK Samadia	RS Singh DK Samadia	
Bael	07	RS Singh	RS Singh	
Date palm	46	RS Singh DK Samadia	RS Singh	
Phalsa	03	DK Samadia	RS Singh	

b) *Aonla* (Arun Kumar Shukla)

For the collection of *aonla* germplasm, three explorations (six trips) were made under NATP on plant bio-diversity covering parts of Rajasthan, Gujarat and Himachal Pradesh, where natural seedling population of *aonla* existed. A total 26 elite seedling were identified and collected bud-wood of elite genotypes was top worked on the existing seedling rootstocks at the *aonla* germplasm block of CIAH, Bikaner from 2001 to 2003. After *in situ* establishment in the field gene bank, during the year 2003-04 observations on plant growth characters were recorded to evaluate and characterize the *aonla* germplasm under hot arid environment.

c) *Lasora* (R.S. Singh and D.K. Samadia)

Two explorations, one each in May 2000 and May 2001, were made under NATP programme for the survey, identification and collection of *lasora* germplasm from parts of arid, semi-arid and sub-humid agro-climate of Rajasthan. A wide range of diversity was observed, recorded and 65 accessions were collected from the region explored. Promising elite trees have been identified and seedling progenies are being maintained for evaluation and characterization at CIAH, Bikaner. During 2003- 04, 65 genotypes of *lasora* were evaluated for survival, vegetative growth, flowering and fruiting characters under hot arid environment. All the genotypes are surviving and growing well under Bikaner conditions. After two years of planting, the maximum plant height 2.7 m and tree' main stem girth 10 cm was recorded in AHCM 26 followed by AHCM 01 (2.4 m and 7.0 cm, respectively). A wide range of variations was recorded for leaf size *i. e.* leaf length (10.6 to 21.0 cm) and leaf width (8.8 to 21.0 cm).

C. Characterization of vegetable crop germplasm (D. K. Samadia)

As a result of an exploration for the collection of cucurbitaceous vegetables particularly the gourds from tribal areas of Rajasthan and Gujarat, sixty collections were made from arid, semi arid and sub humid parts of Ajmer, Bhilwara, Chittorgarh, Banswara, Dungarpur, Udaipur, Sirohi, Rajsamand, Pali and Jodhpur in Rajasthan and Jalod, Dahod, Godhra, Baria, Piplod and Lunawada of Gujarat. The collections comprised of bottlegourd (18), ridgegourd (19), spongegourd (15), bittergourd (3), pumpkin (4) and cucumber (1). These collections were evaluated in *kharif* season of 2003 at CIAH, Bikaner for the characterization and seed multiplication to conserve the landraces (Table 53).

a) Bottlegourd

Eighteen bottlegourd landraces including two wild types collected from parts of arid and semi arid areas of Rajasthan and Gujarat under NATP on plant bio-diversity were evaluated along with two advanced selections during *kharif* season of 2003 at CIAH, Bikaner for the characterization and multiplication of the seeds of the collected material. Detailed observations were recorded on growth, flowering, fruiting, maturity, and fruit yield and quality components. Detailed observations were compiled to characterize and categorized the germplasm under hot arid climate. Among landraces, AHLS 23, 24, 27 and 28 were unique material for multiple characters. A set of multiplied seeds of 20 accession of bottlegourd has been deposited for the long-term conservation in the National Gene Bank at NBPGR, New Delhi.

b) Ridgegourd

Nineteen ridgegourd accessions collected from parts of arid and semi arid areas of Rajasthan and Gujarat under NATP on plant bio-diversity were evaluated along with one advanced selection during *kharif* season of 2003 at CIAH, Bikaner for the characterization and multiplication of the seeds

of the collected material deposited. Detailed observations were recorded on growth, flowering, fruiting, maturity and fruit yield and quality and also seed character components. Detailed observations were compiled to characterize and categorized the germplasm under hot arid climate. The potential genotypes were AHRG 1, 4, 8 and 15 for economical attributes. A set of multiplied seeds of 20 accession of ridgegourd has been deposited for the long-term conservation in the National Gene Bank at NBPGR, New Delhi.

Table 53. Characterization of vegetable crop germplasm at CIAH

Crops	Accessions	Source of material
Minor cucurbits		
Cucumis melo var. callosus	51	NBPGR, Regional station; Jodhpur
C. melo var. agrestis	12	NBPGR, Regional station; Jodhpur
C. melo var. momordica	28	NBPGR, Regional station; Jodhpur
C. sativus	04	NBPGR, Regional station; Jodhpur
C. *prophaterum*	02	NBPGR, Regional station; Jodhpur
C. trigonus	01	NBPGR, Regional station; Jodhpur
C. hardwickii	11	NBPGR, Regional station; Jodhpur
Luffa hermophodita	01	NBPGR, Regional station; Jodhpur
Major cucurbits		
Cucumis melo	55	CIAH, Bikaner
C. melo var. utilissimus	15	NBPGR, Regional station; Jodhpur
Citrullus lanatus	28	NBPGR, Regional station; Jodhpur
Praecitrullus fistulosus	14	NBPGR, Regional station; Jodhpur
Lagenaria siceraria	18	CIAH, Bikaner
Luffa acutangula	19	CIAH, Bikaner
Luffa cylindrica	15	CIAH, Bikaner
Momordica charantia	04	CIAH, Bikaner
Solanaceous		
Capsicum annuum	52+18=70	CIAH, Bikaner and GAU, Vejapur
Lycopersicon esculentum	14	GAU, Vejapur
Solanum melongena	05+21=26	CIAH, Bikaner and GAU, Vejapur
Minor beans		
Lablab purpureus (Sem)	18+20=38	CIAH, Bikaner and GAU, Vejapur
Canavalia gladiata (sword bean)	01	CIAH, Bikaner

c) Spongegourd

Fifteen spongegourd accessions collected from parts of arid and semi arid areas of Rajasthan and Gujarat under NATP on plant bio-diversity were evaluated during kharif season of 2003 at CIAH, Bikaner for the characterization of germplasm and multiplication of the seeds of the collected material. Detailed observations were recorded on growth, flowering, fruiting, maturity and fruit yield and quality and also seed character components. Detailed observations were compiled to characterize and categorized the germplasm under hot arid climate. The genotype AHSG 4, 5 and 13 were most potential for earliness, higher fruit set and fruit quality traits under arid conditions. A set of multiplied seeds of 15 accession of spongegourd has been deposited for the long-term conservation in the National Gene Bank at NBPGR, New Delhi.

d) Bittergourd

Four bittergourd land races collected from tribal areas of Rajasthan and Gujarat were evaluated during kharif season of 2003 at CIAH, Bikaner for the characterization of the germplasm and seed multiplication of the collected material. Detailed observations were recorded on growth, flowering, fruiting, maturity and fruit yield and quality and also seed character components. Detailed observations were compiled to characterize and categorized the germplasm under hot arid climate. A set of multiplied seeds of 03 accession of bittergourd has been deposited for the long-term conservation in the National Gene Bank at NBPGR, New Delhi.

Project: Standardication of fertigation and water requirement of arid fruit crops under micro-irrigation system for arid ecosytems

(B.D. Sharma, R. Bhargava and P.L. Saroj)

Objectives

1. To evaluate the efficacy of drip and micro sprinkler vis a vis conventional method in terms of water and fertilizer economy in arid fruit crops.
2. to standardize the fertigation technique and fertilizer and water requirement at different stges of crop growth under soil-climatic conditions of arid eco-region under micro-irrigation system.
3. to compare growth, development, yield and fruit quality parameters under micro-irrigation and conventional methods.
4. To standardized optimum wetting area for different growth stages of arid fruit crops.

Lead centre:

Cooperating center: Central Institute for Arid Horticulture (ICAR), Bikaner (Rajasthan) Principal

Investigator: Dr. B.D. Sharma,

Duration of project: July 1999 to December 2004

Total Budget allocation: Rs. 22.59 lakhs

Achievement of the projects

To evaluate the efficacy of drip and micro sprinkler vis a vis conventional method in terms of water and fertilizer economy in arid fruits crops.

Evaluation of different irrigation systems and level of irrigation in different crops.

In pomegranate and ber fruit crops, efficiency of different irrigation systems and irrigation levels have been evaluated. The data on mean fruit yield, water applied in particular treatment have been estimated from the fruit yield and water application per plant per year. From these data, saving of water and water use efficiency in each treatment has been evaluated. The data revealed that in pomegranate maximum water use efficiency (1.07q/ha-cm) was observed at 0.75 CPE through drip irrigation followed in 1.00 level through micro sprinkler irrigation system. In bubbler and open channel system, the WUE was low. In ber crop also the trend was more or less same, besides that the quantum of water use efficiency was nearly double than the pomegranate fruit crop. Thus data revealed that ber crop uses water more efficiently than pomegranate crop (Table 54).

Collection of meteorological parameters

The data on evaporation, rainfall, maximum, minimum temperatures, relative humidity and wind speed were collected from the observatory of CIAH, Bikaner. The data on above parameters are given in the below table 55.

Collection and analysis of soil samples

The soil samples of four depths i.e. 0-15, 15-30, 30-45 and 45-60cm have been collected from all three orchards for analyzing the initial soil fertility levels of respective orchard. The soil samples have been processed for physico-chemical analysis and analysis work is under progress. The soils are loamy sand having 82.5% fine sand, 10.2% coarse sand, 4.3% silt and 3.0% clay content. The soil pH and electrical conductivity of the experimental field varies from 7.8 to 8.0 and 0.11 to 0.14dSm^{-1}. The soil samples were analyzed for N, P, K, Zn, Cu, and Fe. The data revealed that the experimental soils are deficient in available N (115kgha^{-1}), P (8.5kg ha^{-1}) and rich in available K (186 kg ha^{-1}). All micronutrients are in medium range except iron, which was in sufficient range (52 ppm)

Table 54. Water use efficiency, yield and water saving under different irrigation systems.

Irrigation System	Irrigation level	Mean yield (q ha-1)	Water applied per ha per year (cm)	Saving of water (%)	WUE (q/ha-cm)
Pomegranate					
Micro sprinkler	1.00CPE	38.50	38.50	-	1.00
	0.75 CPE	26.00	28.88	25	0.90
	0.50 CPE	16.50	19.25	50	0.86
Drip	1.00CPE	35.50	38.50	-	0.92
	0.75 CPE	32.00	28.88	25	1.07
	0.50 CPE	17.00	19.25	50	0.88
Bubbler	1.00CPE	27.00	38.50	-	0.70
	0.75 CPE	20.50	28.88	25	0.71
	0.50 CPE	14.00	19.25	50	0.73
Open channel	1.00CPE	22.00	38.50	-	0.57
	0.75 CPE	16.00	28.88	25	0.56
	0.50 CPE	12.00	19.25	50	0.62
Ber					
Micro sprinkler	1.00CPE	55.00	28.00	-	1.96
	0.75 CPE	42.00	21.00	25	2.00
	0.50 CPE	26.50	14.00	50	1.86
Drip	1.00CPE	54.00	28.00	-	1.93
	0.75 CPE	50.00	21.00	25	2.30
	0.50 CPE	25.00	14.00	50	1.78
Bubbler	1.00CPE	42.00	28.00	-	1.50
	0.75 CPE	32.00	21.00	25	1.52
	0.50 CPE	21.50	14.00	50	1.53
Open channel	1.00CPE	36.00	28.00	-	1.29
	0.75 CPE	28.00	21.00	25	1.33
	0.50 CPE	18.50	14.00	50	1.30

Fertigation schedules are also in progress with all crops and data will be presented after completing the fertirrigation schedules.

Table 55. Meteoriological data at CIAH, Bikaner

Month	Temperature		R.H. (%)		Total rainfall (mm)	No. of rainy days	Wind velocity (km/hr)	Evaporation (mm/day)
	Max.	Min.	Max.	Min.				
April 2003	39.3	22.6	45	13	00.0	0	09.2	11.9
May	43.0	26.1	41	24	00.0	0	15.5	14.1
June	42.6	28.2	54	20	00.0	0	18.4	16.6
July	37.6	25.5	68	36	00.0	0	14.9	12.4
August	36.3	23.4	65	38	08.0	2	11.7	10.2
September	35.8	22.8	67	52	64.5	6	05.4	08.3
October	33.5	17.6	62	42	18.5	4	04.2	07.5
November	28.5	13.5	54	34	00.0	0	03.2	05.4
December	24.5	08.4	56	32	02.3	1	03.0	04.2
January 2004	22.4	04.5	52	25	00.0	0	02.3	03.2
February	24.5	06.8	48	23	00.0	0	04.2	04.2
March	28.9	12.8	42	18	00.0	0	04.5	06.5

The evaporation data was used to calculate the total water requirement of the different crops. Accordingly, the irrigation through different systems was given to the crops.

To standardize the fertigation technique and fertilizer and water requirement at different stages of crop growth under soil-climatic conditions of arid eco-region under micro-irrigation system

Monitoring of irrigation water and fertilizer application.

The daily irrigation water requirement for ber, pomegranate and kinnow plants have been worked out. The planting distance, crop factors, pan factor, wetting zone and fraction of pan evaporation parameters have been considered for calculating the water requirement of the crop.

For ber crop, the crop factor 0.6, pan factor; 0.7; planting distance; 6 * 6 meter, percent area covered by foliage (wetted zone), 40 percent have been standardized on the basis of crop stage. The required amount of irrigation water has been calculated and applied through different methods of irrigation.

The five-year-old pomegranate fruit crop, pan factor, 0.7; planting distance, 5 * 5 meter, crop factor, 0.55, and wetting area, 25 percent have standardized. Considering the efficiency of drippers, exact amount of water to be given to the crop has also been calculated and required amount of irrigation water has been applied through different irrigation methods.

The kinnow plants are two year old and on the basis of crop age and their growth, pan factor, 0.7; crop factor, 0.5; planting distance, 6 * 6 meter; area to be wetted, 20 per cent have been standardized. On

the basis of dripper efficiency and fraction of pan evaporation, the required amount of irrigation water would have been applied.

Standardization of fertigation schedules.

N, P and K are being applied through water-soluble fertilizers with the help of water injecting system (Venturi) in drip and micro-sprinkler irrigation systems. In pipe and conventional irrigation systems, the required amount of N, P and K fertilizers is being given to the plant with irrigation water (Table 56). In drip and micro-sprinkler systems, the recommended amount of fertilizers were splitted as per the growth stages of the crops.

Table 56. Recommended doses of N, P and K are as follows

Crop	N (gm plant^{-1})	P (gm plant^{-1})	K (gm plant^{-1})	No of splits	Time of fertigation
Ber	600	250	125	28	June to December
Pomegranate	750	300	125	32	June to January
Kinnow	750	350	750	40	May to February

In ber fruit crop, the water-soluble fertilizers containing N, P and K were injected through Venture from June to December at weekly intervals. In pomegranate fruit crop, fertirrigation was done from the June to January and in Kinnow, fertirrigation was done from May to February at weekly basis.

In all treatments, the plants were given basal dose of organic manure in the form of vermicompost @ 20kg plant^{-1} over and above the recommended doses of N, P and K. The vermicompost was having N, P and K 1.24, 0.65 and 1.50 per cent besides micro and secondary nutrients. The amounts of the fertilizer have been standardized. During crop growth and flowering stage the nitrogen, phosphorus and potassium have been given in the ratio of 1:1:1 while during fruit set and maturity, the nitrogen and potassium have been applied in the ratio of 1:3 in all crops.

Growth, development, yield and fruit quality parameters under micro-irrigation and conventional methods

The plant height, spread and stem diameter were recorded in each month in pomegranate and kinnow fruit crops while in ber crop, the plant growth data were recorded from the month of July 2003 to January 2004.

Ber

Data revealed that in ber crop, the maximum plant height (3.50m) was recorded in micro sprinkler at 1.00CPE irrigation level, which was statistically at par with 1.00 and 0.75CPE irrigation levels through drip and minimum plant height (2.50m) was observed in open channel system. The

fertirrigation levels also influenced the plant height and in 100 and 75% recommended doses of N, P & K through drip and 100% recommended dose through micro sprinkler, plant height was statistically at par. In similar way, plant spread and stem diameter were also in the same pattern. The maximum fruit yield (45.0 t ha^{-1}) was recorded in 0.75CPE through micro sprinkler and which was statistically at par with 1.00CPE through drip followed by 0.75CPE through drip and minimum fruit yield was recorded in open channel system. Under drip and micro sprinkler systems at 1.00 and 0.75CPE, the NPK status was statistically at par and higher over bubbler and open channel irrigation system. Application of 100 and 75% of recommended doses of NPK through drip and micro sprinkler systems increased the levels of N, P, K, Zn, and Fe in leaf tissues. The irrigation levels also have influenced the fruit quality and maximum TSS (22 degree brix), low acidity (0.15%) and high pulp stone ratio (21:1) were recorded in 1.00CPE through micro sprinkler and 1.00 and 0.75CPE through drip irrigation.

Pomegranate

In pomegranate fruit crop, it was decided that in pomegranate, *mrig bahar* crop will be harvested and accordingly the watering was withhold and irrigation was started from the month of June 2003. The flowering was started in the last week of July and completed by the end of August. In all treatment flowering pattern was more or less same. On an average 40-45 numbers of fruit will be kept on each plant. The maximum plant height (2.10m), plant spread (1.50 × 1.45m) were recorded in 1.00CPE through micro sprinkler and statistically at par with 1.00 and 0.75CPE levels of drip irrigation. The fertirrigation of NPK nutrients also influenced the plant growth parameters and observed that maximum plant height 2.15 was measured in 100% recommended doses of NPK and statically at par with 75% RD of NPK and at 50% RD, the plant growth has been reduced significantly.

The fruit yield has been influenced by system of irrigation, level of irrigation and fertirrigation doses and data revealed that the maximum fruit yield (35.5tone ha^{-1}) was estimated in 1.00CPE level of irrigation through micro sprinkler, which was statistically at par with 0.75CPE through micro sprinkler, 1.00 and 0.75CPE irrigation level through drip. In bubbler and open channel irrigation system, fruit yield has been reduced significantly in comparison to micro sprinkler and drip systems. Data also revealed that fruit yield has not been reduced significantly up to 75% RD of NPK and below this level, the yield has been reduced.

Kinnow

The kinnow plants are still in vegetative phase and the increment in plant height, spread and stem diameter over initial values has been recorded in each month. System of irrigation, level of irrigation and fertirrigation levels has affected the growth pattern. The data recorded in February 2004 revealed that maximum plant height (1.45m), spread (1.65 × 1.35m) was in micro sprinkler irrigation system followed by drip and minimum plant height (0.60m) in open channel system. Only in micro sprinkler and drip irrigation system, the flowering and fruit set in the month March 2004 has been

observed. The leaf nutrient analysis revealed that maximum N (2.35%), P (0.56%) and K (2.20%) contents were estimated in 100 and 75% RD of NPK.

Optimum wetting area for different growth stages of arid fruit crops.

The soil moisture status was measured under different irrigation systems and irrigation levels in kinnow fruit crop. The soil moisture was monitored through TDR meter at certain horizontal and vertical distances from the main stem of the plant. Data revealed that irrigation through micro sprinkler at 1.00CPE irrigation level provided the moisture at field capacity (8.8%) up to 85cm horizontal distances and 60cm vertically deep depths for 4 days after irrigation. In open channel and bubbler irrigation system the sufficient moisture (Field capacity) only up to 24 hrs of the irrigation.

Project : Develop sustainable agri-silvi-horti production system for marginal lands under arid conditions (S.S. Hiwale and P.L.Saroj).

Lead Centre : CHES, Godhra
Cooperative Centre : CIAH, Bikaner

AT CIAH, Bikaner

A. Evaluation of ber based agroforestry system

Ber based agri-horti system was initiated in September 2000 under irrigated arid conditions. The ber cultivar Gola was planted at 6 × 6 , 8 × 8 and 16 × 4 m spacing. The groundstorey crops were introduced from Kharif 2001 having crop combination of groundnut-wheat, cluster bean - mustard and Indian aloe.

I. Overstorey component

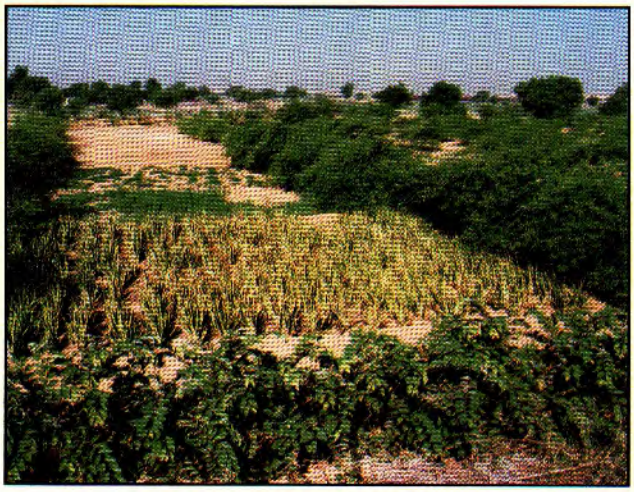
(i)Survival and growth of ber plants

In situ budded ber cv Gola plants are in fourth year of their age and are growing well under normal field management practices. Data on the survival and plant vigour are being recorded at six months interval under different treatments combinations. At this stage, mortality of ber plants is not observed in the field and the plant survival is more than 90 per cent in all the treatments except in sole plantation (88.63%).

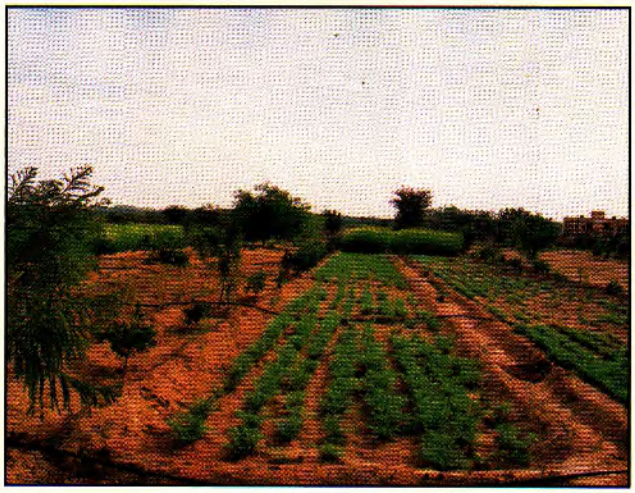
Ber plants are responding to the inputs applied to groundstorey crops, which is evident by the vigour of plants. Even in the fourth year of age, plant spacing has no marked influence on the plant vigour parameters but the crop rotations have marked difference on the growth and vigour of the ber plants.

Data presented on plant height, crown spread, stock diameter and scion diameter and scion:stock ratio in table 57-61 respectively revealed that at this stage, there were no influence of plant spacing on the vigour of ber plants but the crop rotation has influence the vigour of the plants. At present, the plant height is 2.12, 2.29, 2.47 and 2.03 m under Groundnut Wheat, Cluster bean Mustard, Indian aloe and sole plantation, respectively (Table 57). Similarly, the plant spread is 2.70, 2.89, 3.11 and 2.59 m^2 under same set of treatment combinations. The data on plant spread (Table 58) indicated that the spread was more than the plant height due to spreading nature of *Gola* cultivar.

The same trend was recorded in stock (Table 59) and scion diameter (Table 60) and least variation was observed among different treatments. The scion and stock ratio was also computed (Table 61) to see the vegetative compatibility of the component plants but there were no such symptoms of incompatibility. The scion:stock ratio varied from 0.88 to 0.93, hence components are compatible to each other.



Ber Based multistata cropping system



Aonla based multistata cropping system

Table 57. Plant height (m) Sept. 2003.

Crop rotation	Spacing (m)			
	6x6	8x8	16x4	Mean
Groundnut Wheat	2.11	2.08	2.17	2.12
Cluster bean Mustard	2.23	2.29	2.34	2.29
Indian Aloe	2.43	2.46	2.52	2.47
Sole plantation	2.04	1.98	2.08	2.03
Mean	2.20	2.21	2.28	

Table 58. Plant spread (m^2) Sept. 2003.

Crop rotation	Spacing (m)			
	6x6	8x8	16x4	Mean
Groundnut Wheat	2.69	2.74	2.68	2.70
Cluster bean Mustard	2.88	2.93	2.85	2.89
Indian Aloe	3.11	3.04	3.18	3.11
Sole plantation	2.55	2.60	2.63	2.59
Mean	2.81	2.83	2.84	

Table 59. Stock diameter (cm) Sept. 2003

Crop rotation	Spacing (m)			
	6x6	8x8	16x4	Mean
Groundnut Wheat	4.42	4.49	4.53	4.48
Cluster bean Mustard	4.26	1.38	4.43	4.36
Indian Aloe	4.59	4.71	4.74	4.68
Sole plantation	4.16	4.21	4.19	4.19
Mean	4.36	4.45	4.47	

Table 60. Scion diameter (cm) Sep. 2003

Crop rotation	Spacing (m)			
	6x6	8x8	16x4	Mean
Groundnut Wheat	3.94	3.98	3.92	3.95
Cluster bean Mustard	4.08	4.01	3.98	4.02
Indian Aloe	4.23	4.26	4.33	4.27
Sole plantation	3.95	3.83	3.88	3.89
Mean	4.05	4.02	4.03	

Table 61. Scion: Stock, Sept. 2003

Crop rotation	Spacing (m)			
	6x6	8x8	16x4	Mean
Groundnut Wheat	0.89	0.89	0.87	0.88
Cluster bean Mustard	0.96	0.92	0.90	0.93
Indian Aloe	0.92	0.90	0.91	0.91
Sole plantation	0.95	0.91	0.93	0.93
Mean	0.93	0.91	0.90	

At CHES, Godhra

Agri-Horti Production system on Marginal lands.

All the growth parameters of Aonla increased over the previous year in 9 years old plants. However growing of intercrops did not influence it. Data on yield and biomass production revealed that yield of main crop and intercrops increased over the previous year. Land equivalent ratio was maximum in Aonla+ Sesamum. Economics of the system indicated that Aonla + Okra produced maximum net return of Rs. 80390/- . B: C ratio (8.85) was highest in Aonla+ Sesamum.

Similar trend was recorded in intercropping with Custard apple in respect of vegetative growth of main & intercrop. Whereas, highest land equivalent ratio was recorded in Custard apple + Okra. Highest net return/ha (Rs. 14778/-) and B:C ratio (1.63) was obtained in Custard apple + Okra.

Agri-Silvi Production system on Marginal lands

In Neem based cropping system understorey crops did not influence the growth of main crop. There was increase in all the growth parameters of the main crop. Economics of the system worked out revealed that if Neem is harvested in the fifth year maximum net return (Rs.13704/-) was obtained from Neem + Cenchrus cropping system.

In Subabool based cropping system, no understorey crop could be grown successfully due to the shade and damage by birds. If Subabool was harvested in the 12^{th} year, will give a net return of Rs. 41700/- to Rs.47500/- with a B: C ratio of 2.48 to 2.87 with different intercrops.

Leaf litter fall & its decomposition in tree species and nutrient recycling

All the four tree species were of deciduous types and hence added large amount of leaf litter to soil. On dry weight basis, maximum leaf litter (8.5kg/plant) was added by Aonla. Maximum amount of N, P, K also therefore recycled per plant by Aonla. However on hectare basis it was Subabool, which recycles maximum N, P, K. Decomposition rate was faster Subabool leaf litter after a period of two months (46.80%). Leaf nitrogen and phosphorus content of decomposed leaf litter was higher than undecomposed, whereas, potassium content decreased in all the tree species.

Rainfall, runoff and soil loss under different tree species

During the year about 426 mm rainfall caused soil erosion in different spells. The tree species and their spacing have a bearing on amount of soil loss through erosion. In Subabool where close spacing was adopted the soil loss was less (0.65 q/ha) whereas, in case of Aonla where the spacing was 10x10m the soil loss increased to 1.20 q/ha. Though there was not much difference in amount of runoff water causing erosion.

Distribution of roots and crown Characteristics of Horti-silvi tree species

Maximum below ground biomass (48.90 kg/tree) and above ground biomass (264 kg/tree) was recorded in 12 years old Subabool, whereas root: shoot ratio was maximum in Aonla (0.58). Rooting depth and horizontal spread was highest in Neem (129.40 cm and 4.12 m, respectively).

Specific gravity of wood, Charcoal production and its quality

Studies on specific gravity of wood and subsequent charcoal production in the four tree species indicated that Neem wood had highest specific gravity (0.97), whereas maximum charcoal was produced by Custard apple (40%). Maximum Ash (90g/kg Charcoal) was produced in Aonla wood after complete burning. One kg Aonla wood burnt for longer duration (2.15hrs).

(ii) Fruit yield of ber

At the age of three years, the overstorey component ber cv Gola came in flowering followed by good retention of quality fruits. An average yield of 38.93, 22.07 and 23.01 q/ha fruits were harvested from the plots of 6x6, 8x8 and 16x4m, respectively. The higher level of yield in the plot of 6x6m as against 8x8 and 16x4m plots is due to the presence of more number of plants per hectare. The average individual plant yield tells us that the spacing did not influence on the yield of ber cv Gola at this stage. On an average, ber cv Gola plants produced 14.05, 14.15 and 14.75 kg fruits / plant in 6x6, 8x8 and 16x4m plots, respectively. On the other hand, the different crop rotations applied in the experiment have remarkable influence on the yield of ber cv Gola fruits. The yield recorded from different crop rotations was 26.43, 27.30, 41.18 and 14.75 q/ha from groundnut-wheat, cluster bean-mustard, Indian aloe and sole plantation, respectively. Higher yields from groundnut-wheat, cluster bean-mustard and Indian aloe crop rotations as against sole plantation clearly showed that the input applied to the groundstorey crops in the form of nutrients and water cumulatively enhanced fruit yield of ber cv Gola in these treatments as compared to sole plantation of ber plants. The highest yield was recorded from Indian aloe plots whereas; the yield from groundnut-wheat and cluster bean-mustard plots was at par. In sole plantation, lowest fruit yield was recorded (Table 62).

Table 62. Fruit yield of ber cv Gola under different treatment combinations (q/ha)-2004

Crop rotation	Spacing (m)			
	6x6	8x8	16x4	Mean
Groundnut-Wheat	37.40 (13.50)*	20.36 (13.05)	21.53 (13.80)	26.43
Cluster bean-Mustard	38.00 (13.72)	22.07 (14.15)	21.84 (14.00)	27.30
Indian Aloe	57.48 (20.75)	32.52 (20.85)	33.54 (21.50)	41.18
Sole ber	22.85 (8.25)	13.35 (8.56)	15.13 (9.70)	17.11
Mean	38.93 (14.05)	22.07 (14.15)	23.01 (14.75)	28.00

* Figures in parenthesis are average yield of individual plants

(iii) Size and quality of ber fruits

Since, different groundstorey crops were grown with ber which influence the growth and yield of ber, therefore it essential to assess the physico-chemical parameters of ber fruits also. The data presented in table 63 indicated that the fruits were enough bold (average weight of individual fruit-27.25 g) and acceptable quality (TSS-18.60 ^{0}B and acidity-0.21%). The size and quality were almost at par in all the treatments except under sole plantation of ber, where smaller size of fruits was obtained but TSS was slightly higher. On the other hand the fruit weight of ber with Indian Aloe was maximum (28.62 g) but acidity was also higher.

Table 63. Physico-chemical parameters of ber fruits under different treatment combinations 2004

Parameters	Treatment combinations				
	Groundnut-wheat	Cluster bean-mustard	Indian Aloe	Sole ber	Mean
Av. fruit wt.(g)	27.20	27.05	28.62	26.15	27.25
Seed wt. (g)	01.82	01.80	01.96	01.73	01.82
Pulp: Stone	14.95	15.03	14.60	15.12	14.92
T.S.S (0B)	18.20	18.50	17.86	19.85	18.60
Acidity (%)	00.21	00.20	00.23	00.20	00.21

(IV) Fuel wood production

After harvesting the fruits, when leaves start senescence stage, the plants are pruned in the month of April by leaving 50% current year extension shoot. Data given in table 64 revealed that the higher fuel wood (10.39 q/ha) was obtained at closer spacing (6x 6 m) than wider spacing (16x4 m and 8x8 m) i.e. 5.89 and 5.65 q/ha respectively. Among different crop rotations, the highest fuel wood was recorded in ber +Indian aloe (8.79 q/ha) while lowest in sole plantation (7.31 q/ha). The fuel wood production was directly proportion to vigour of the plants.

Table 64. Fuel wood production (q/ha) from ber trees under different treatment combinations-2004 (on dry weight basis)

Treatments	Spacing (m)			
	6 x 6	8 x 8	16 x 4	Mean
Groundnut-Wheat	10.66(3.85)	5.42(3.48)	6.08(3.90)	7.39 (3.74)
Cluster bean-Mustard	10.53(3.80)	5.96(3.82)	5.94(3.81)	7.48 (3.81)
Indian Aloe	12.47(4.50)	6.71(4.30)	7.20(4.62)	8.79 (4.47)
Sole ber	7.89(2.85)	4.52(2.90)	4.36(2.80)	5.59 (2.85)
Mean	10.39(3.75)	5.65(3.62)	5.89(3.78)	7.31 (3.71)

Figures in parentheses are kg/plant

II. Groundstorey components

(i) Crop yield

Now, all the components viz., groundnut, wheat, cluster bean, mustard, Indian aloe as groundstorey components and ber cv Gola as overstorey component are in production phase. Since different components are integrated into the production system, multiple outputs were harvested from the field. From groundnut dried pods; from cluster bean green pods (for vegetable purpose); from wheat and mustard grain yield; from Indian aloe green leaf pad and suckers (as planting material) and from ber fruits, besides considerable amount of biomass from almost all the components were harvested third year of cropping. Data presented in table 65 indicated that 6.94, 82.94 and 27.68 q/ha yields from groundnut, cluster bean, and Indian aloe, respectively was harvested during third year of cropping under this system. It is also obvious that there was no much influence of plant spacing on the yield of groundstorey crops but slightly better yield was obtained under sole cropping in all the crops during third year also which is perhaps the outcome of the more cropping space for the crops in the sole cropping. Even after restricted irrigation the yield of India aloe was very good but it was less than the year 2003.

Table 65. Yield of *Kharif* groundstorey crops with ber based AFS (q/ha) -2003.

Spacing	Groundstorey crops		
	B. Kharif		Perennial Crop
	Groundnut*	Cluster bean**	Indian Aloe***
	2003	2003	2003
6 X 6 m	6.95	81.67	27.9
8 X 8 m	6.60	82.45	26.8
16 X 4 m	7.05	82.57	27.3
Sole	7.15	85.05	28.7
Mean	6.94	82.94	27.68

* Dry pod yield ** Green pod yield *** Green leaf pad yield in second harvest

During *Rabi* season, the data presented in table 10 revealed that the average grain yield of wheat was 13.80, 15.35, 15.60 and 16.52 q/ha in 6x6, 8x8, 16x4m and sole cropping, respectively. Similarly, average grain yield of mustard was recorded as 11.40, 13.20, 13.12 and 14.30 q/ha from the same set of treatments. The marginal differences in yield of groundstorey crops indicated that there was no influence of overstorey component on the yield reduction of crops at initial years. Third cut of leaf pad of Indian aloe during *Rabi* season produced an average yield of 21.45 q green leaf pad/ha. However, there was marginal difference in the yield of green leaf pad at 16x4 m and 8x8 m spacing but the highest

yield was recorded from the sole cropping of Indian aloe (23.55 q/ha) and lowest at 6x6 m spacing (Table 66).

Table 66. Yield of *Rabi* groundstorey crops with ber based AFS (q/ha)- 2004

Spacing	Groundstorey crops		
	D. Rabi		Perennial Crop
	Wheat	Mustard	Indian Aloe*
6 X 6 m	13.80	11.40	19.50
8 X 8 m	15.35	13.20	21.15
16 X 4 m	15.60	13.12	21.60
Sole	16.52	14.30	23.55
Mean	15.31	13.00	21.45

*Green leaf pad yield of one cut

(ii) Sucker yield

The suckers arising from the base of Indian aloe plants were also harvested as planting materials (Table 67). In *Rabi* season, an average of 90541 and 112502 number of suckers/ha were produced in Indian aloe+ber and sole Indian aloe, respectively. The higher numbers of suckers were obtained from sole Indian aloe plots whereas; it was reduced to a considerable extent in Indian aloe+ber plot. The difference in yield of sucker production was due to availability of per ha orchard area under different treatment combinations.

Table 67. Production of suckers of Indian Aloe in ber based agroforestry system.

Treatment	Number of suckers/ha
Indian Aloe+Ber (6x6m)	90541
Indian Aloe+Ber (8x8m)	100200
Indian Aloe+Ber (16x4m)	100504
Indian Aloe+Ber (16x4m)	112502

(iii) Biomass yield of groundstorey crops

Since, the experiment was initiated under marginal land, hence production of biomass and their incorporation after decomposition in the same ratio from the field where it was harvested is also essential to quantify. In the present investigation, the biomass production, both above ground and below ground were recorded for all the crops except Indian aloe. The total biomass production from different groundstorey crops was also computed. It is evident from the data presented in table 68 and 69 that high

variation in above ground and below ground biomass production was recorded in different crops which is due to the diverse growing nature and specific root: shoot ratio of the component crops. In the *Kharif* season, the total biomass production was 24.26 and 57.36 q/ha from groundnut and cluster bean respectively. Similarly, in *Rabi* season cropping, total biomass production was 47.94 and 23.59 q/ha from wheat and mustard, respectively. The above ground biomass was about two times in wheat and it was approximately seven times in mustard, suggesting the varying root: shoot ratio of these crops.

Table 68. Biomass production of Kharif crops (q/ha)*

Spacing	Groundstorey crops					
	Groundnut			Cluster bean		
	Above ground	Below ground	Total	Above ground	Below ground	Total
	2003	2003	2003	2003	2003	2003
6 x 6 m	19.80	3.57	23.37	50.35	3.40	53.75
8 x 8 m	21.05	3.80	24.85	53.57	3.20	56.77
16 x 4 m	20.47	3.45	23.92	56.70	3.65	60.35
Sole crop	20.81	4.10	24.91	54.65	3.92	58.57
Mean	20.53	3.73	24.26	53.82	3.54	57.36

* - Dry weigh basis

Table 69. Biomass production of Rabi crops *-2004

Spacing	Groundstorey crops					
	Wheat			Mustard		
	Above ground	Below ground	Total	Above ground	Below ground	Total
6 x 6 m 32.57	13.75	46.32	19.20	02.55	21.75	
8 x 8 m 34.65	14.61	49.26	21.20	02.50	24.00	
16 x 4 m34.50	14.50	49.00	21.00	02.60	23.60	
Sole crop	34.00	13.20	47.00	22.25	02.78	25.03
Mean	33.93	14.01	47.94	20.98	02.60	23.59

* - Dry weight basis

Project 4. Horticulture and vegetable gardening for food and nutritional security (JAYVIGYAN Household food and Nutritional Security)

House hold Food and Nutritional Security for tribal, backward and hilly, areas.

In-situ budding performance of ber cv. Gola, Goma Kirti and Umran " Goma Kirti" was found to perform better than rest of the two cultivars viz, Gola and Umran with maximum plant height

(308.15 cm.), plant spread (418.70 cm.), stem girth.(24.86 cm), average fruit weight (20.30 gm.), fruit length (5.37 cm), fruit circumference (4.49 cm) and mean yield (2.46 Kg/plant.

The overall infestation of both fruit fly and fruit borer ranged from 2.0% to 18.0%, which was effectively control by triweekly sprays with fenvalerate (0.005%) alternately with NSKE 5.0% at 10-day interval.

Varietal trial on Pomegranate cvs.Ganesh,Jyoti,,Ruby,Jalor Seedless and Mridula.

Among the different five cultivars of pomegranate 'Ganesh' was found more suitable followed by 'Mridula' and 'Rubi'with maximum plant height (150.72 cm.), plant spread (N-S-149.21 cm.and E-W 153.33 cm.) and stem girth (16.75 cm.). Schedule involving application of monocrotophos (0.05%) or dimethoate (0.05%) at fortnightly interval alternately with NSKE (5.0%) at weekly interval effectively controlled the pests infesting pomegranate.

Adaptive trial on sweet orange cvs. Sathgudi and Mosambi.

Various growth, yield and qualitative parameters were recorded on seven-year-old plants, the mean yield 52.15 Kg/plant was obtained with an acceptable quality fruits during 2003.Variety showed its suitability with mean plant height 186.00cm.,plant spread N-S: 227.33 cm., E-W : 230.71 cm.and stem girth 28.06 cm.provided irrigation facility is available.

The overall incidence of insect-pest recorded, was effectively checked by tri-weekly sprays with either Dimethote (0.05%) or Acephate (0.05%) followed by NSKE (5.00 %).

High-density orcharding in pomegranate cv. Ganesh

The plants spaced at 5mX5m spacing performed better followed by 5m X3m and 4m X2m spacing. Maximum plant height (2.76m), plant spread (2.68 m) and stem girth (30.44 cm.) were recorded in 5X5 m spaced plant. Fruits obtained from 5 X5 m spaced plants were of better quality with respect to mean fruit weight, fruit diameter and per plant yield followed by 5X3 and 4X2m spaced plants, while spacing 2.5 X 2.5 meter was found optimum for getting higher yield.

Nursery management of fruit crops and vegetable seed production of Horticultural crops

Center has multiplied 1000 plants each of ber, pomegranate and aonla for distributing among the farmers for laying out FLDs.

Front line demonstrations of improved technologies.

More than 100 farmers were contacted and selected for laying out the front line demonstrations and on farm trial of improved technologies of ber, pomegranate and aonla. Farmers are willing to take

field demonstrations on fruit crops but a major constraint is unavailability of irrigation water. So far an area of 10.00 acre of area is covered under FLDs of improved cultivation technology of ber, pomegranate and aonla.

K.3. REVOLVING FUND SCHEME ON COMMERCIAL PROPAGATION OF FRUIT CROPS

Revolving Fund nursery Scheme on "Commercial Propagation of fruit plants

During the period following quantity of plant material was propagated and sold to the government organization and farmers, Mango-3001, Aonla- 1627, Sapota- 2369, Ber (Goma kirti) - 100, Ber (Gola / Umran)-97, Guava (Seedling)-70, Guava (Air layered)-42,Pomegranate- 154, Custard apple- 175 and Kagzilime- 425. The revenue realization was Rs. 2,19,382/- during the year.

C. Adhoc Scheme

Project : Studies on Powdery Mildew of Ber and Standardization of Techniques for Quick Screening

Qualitative nature of protein and their relationship with variability on powdery mildew resistance in different genotypes of ber was studied through electrophoration technique. Immature and matured fruits of cultivars Gola, Umran and Seb, which are susceptible, and Kaithali, Jogiya and Reshmi as moderately susceptible were subjected to SDS-PAGE. A total of 34 protein fractions with Rf ranging from 0.22 to 0.95 were visualized. Intensive and major fractions at 0.22, 0.27,0.63 and 0.86 were resolved in cv. Umran, Seb, and Kaithali. However, bands were very faint or less intensive in Jogiya, Reshmi and Gola. In moderately susceptible genotypes (Kaithali, Jogiya and Reshmi), the protein bands at Rf 0.43,0.50 and 0.90 were observed and there were not present in susceptible cultivars.

Similarly, cultivars viz., Sandur, Nazuk, Dandan, Naram and Sanuer-1 were studied and a total of 35 bands in these genotypes, which are bound with common fractions at R_f ranging between 0.05 to 0.81 except cv. Ponda and Nazuk lacking a band at 0.59 in matured fruits and tender fruits of respective genotypes were seen. Protein profile was also investigated in tender fruits cultivars like Jogiya (MS), Mundia (S), Seedless (R), Villaithi (R), ZG-2 (R) and Tsabtso (MS). The profile was different in each of the genotypes. Jogiya, ZG-2 and Tsabtso shared a common fraction of R_f 0.90. Resistant types possessed more number of protein compared to moderately susceptible and susceptible genotypes. Overall results showed that ber fruits are constituted with different fractions of protein with varying molecular weight and such proteins may also involve in the phylogeny of ber cultivars and powdery mildew reactions. However, further investigations are required for identifying varieties with durable resistance under field conditions.

Farm development

At CIAH, Bikaner

Development and Management of CIAH farm

During the period under report, in addition to the existing area under cultivation, additional 1ha land was leveled for extending the area under aonla plantation. Besides land development farm section is involved in maintenance of orchards on germplasm conservation, production-based crop experiments on fruits and vegetables and seed production blocks, in 46 ha area covering *ber* (12), pomegranate (03), date palm (05), *aonla* (05), progeny block (04), vegetables (02), underutilized fruits (03), *bael* (02), kinnow (02), *khejri,*(01) Plant Pathology (01), Plant Physiology (01) hectares. Windbreak planted around the fenced area is also being maintained through the farm section including landscape work in 05 ha area.

Revenue generation

Through sale of vegetable seeds, sale of fresh fruits, planting material etc., revenue of about Rs. 1,00, 000 (Rupees one lac) was generated during the period under report.

Irrigation system

Water requirement in different blocks is mainly met through (i) IGNP water supply (ii) tube well (iii) overhead tank (5 lakh litre capacity) (iii) water reservoir of 25 lakh litre capacity . These facilities are mainly utilized for giving live saving irrigation to the crops during the lean period through 4" main pipe line laid out in 3 Km area covering 50 hectares area either through open channel, controlled hose pipe, sprinkler or drip system. A new water reservoir of 10 lakh litre capacity is being used for giving live saving irrigation in different experimental blocks such as Aonla based cropping system, Ber based cropping system, Commercial ber block and Bael germplasm block.

Infrastructure facilities

For recording weather data, new agromet station was installed. The recorded data is being used for interpretation of experimental results. For sale of farm produce through single window system, sales counter was constructed near the main gate of the institute. The sale of harvested fruits and vegetables including seed material is now being made through the sales counter. During the period under report, a hall measuring 50' (L)x15' (W) was constructed for taking lunch by the labourers working in the field.

Farm Macchinery and Power

Water tanker of 3000 liter capacity and Tipper type trolley was procured during the period under report.

At CHES, Godhra

Farm Development

So far about 126 ha. land area has been put under cultivation. During the year 7 ha. new area was brought under cultivation of crops like aonla(2 ha).,Bael(1 ha.),Mahuva(1 ha.),Chirounji (1 ha.) & Mango (2 ha.). Action has been expedited for landscaping of block No.II. About 4 ha. area was cleaned and developed with roads, bunds and channels. The ornamental plants like gulmahor, ashok, bougainvillea, etc. were planted along the boundary wall, roads and near office building.

Revenue

A revenue of Rs.2, 04,242 was realized from the sale of various plant material by the RFS in addition to this a revenue of Rs.1,99,432 was realized from the sale of various farm produce.

Staff position

Cadre Strength of the Institute as on 31.03.2004:

Category	Sanctioned Strength	Present strength
Research Management Position	01	01
Scientific	35	24
Administrative	25	24
Technical	42	42
Supporting	37	37
Total	140	128

Staff under A and B as on 31.03.2004

A. Headquarter

S.No.	Name	Designation/Discipline
I.	**Research Management Position**	
1.	Dr. D.G.Dhandar	Director
II.	**Scientific**	
1.	Dr. B.D.Sharma	Sr. Scientist (Soil. Science)
2.	Dr. R. Bhargava	Sr. Scientist (Plant Physiology)
3.	Dr. P.L. Saroj	Sr. Scientist (Horticulture)
4.	Dr. R.S. Singh	Sr. Scientist (Horticulture)
5.	Dr. O.P.Awasthi	Sr. Scietnist (Horticulture)
6.	Dr. P. Nallathambi	Sr. Scientist (Plant Pathology)
7.	Dr. D.K. Samadia	Sr. Scientist (Horticulture)
8.	Dr. Dhurendra Singh	Sr. Scientist (Bio-Technology-Plant Science)
9.	Smt. C. Umamaheswari	Scientist (Plant Pathology)
10.	Dr. Anil Kumar Shukla	Scientist (Horticulture)
11.	Sh. Sumer Singh Meena	Scientist (Vegetable Science)
12.	Dr. Arun Kumar Shukla	Scientist (Fruit Science)

13.	Sh. A. Nagaraja	Scientist (Fruit Science)
14.	Dr. S.R. Meena	Scientist (Agril. Extension)
15.	Dr. I.S. Singh	Scientist (Soil Sci., Soil Phy. & SWC)
III.	**Administrative**	
1.	Sh. V.K. Pandey	Asstt. Admn. Officer
2.	Sh. S.C. Sharma	Asstt. Fin. and Accounts Officer
3.	Sh. Ayaz Ahmed	Asstt. Fin. and Accounts Officer
IV.	**Technical**	
1.	Sh. S.K.Pandey	T-5 (Technical Officer) Farm
2.	Sh. M.K.Jain	T-4 (Sr. Computer)
3.	Sh. P.P.Pareek	T-4 (Hindi Translator)
4.	Sh. G.R. Baria	T-4 (Field Technician)
5.	Dr. U.V.Singh	T-4 (Field Technician)

B. Regional Station (CHES, Vejalpur)

S.No.	Name	Designation/Discipline
I.	**Scientific**	
1.	Dr. B.G. Bagle	Principal Scientist (Ento.) & I/c Head
2.	Dr. Sanjay Singh	Sr. Scientist (Hort.)
3.	Dr. S.S. Hiwale	Sr. Scientist (Hort.)
4.	Dr. H.K. Joshi	Scientist (Sel. Grade) Plant Pathology
5.	Dr. V.V. Appa Rao	Scientist (Soil Science)
6.	Sh. V. Lenin	Scietnist (Agril.Extension)
7.	Sh. A.K. Singh	Scientist (Hort.)
8.	Dr. S. Raja	Scientist (Hort.)
9.	Sh. D.T. Meshram	Scientist (Soil and Water Conservation & Engineering)
II.	**Administrative**	
1.	Sh. J.B. Saxena	Asstt. Admn. Officer
III.	**Technical**	
1.	Sh. D.K. Saraswat	T-8 (Technical Officer) Farm
2.	Sh. Nihal Singh	T-6 (Technical Officer) Farm
3.	Sh. G.U. Trivedi	T-5 (Librarian)
4.	Sh. A.V. Dhobi	T-4 (Overseer)

Finances

Budget allocation and expenditure incurred during 2003-04 are given in table below.

Budget allocation and expenditure incurred during 2003-04

(Rs. in Lakhs)

S.No.	Head	Plan		Non-Plan	
		Allocation	Expenditure	Allocation	Expenditure
1.	Establishment Charges	--	--	162.60	162.49
2.	Wages (Temp. status)	--	--	37.70	37.42
3.	T.A.	3.40	3.23	1.30	1.26
4.	O.T.A.	--	--	0.25	0.25
5.	Works	23.00	23.00	5.57	5.57
6.	Other Charges	95.50	95.49	38.58	38.57
7.	One time catchup grant	--	--	--	--
	Total	121.90	121.72	246.00	245.56

Publications

A. Research papers

Refered journal

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Singh, C., Yadav, P.K. and Samadia, D.K. (2003). Study on growth, yield and quality of onion influenced by nitrogen and row spacing under arid conditions of Rajasthan. Acta Ecologica. 25 (2): 136-138.

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D. Lecture delivered

Dr. Anil Kumar Shukla

Deliver lecture in the practical class of nursery management in one day training program of Agricultural Supervisor organised by CIAH Bikaner.

Dr. D.K. Samadia

Delivered lecture on Technology for vegetable production in arid region. In: Training on innovative techniques in arid horticulture for extension functionaries and agricultural supervisors. Organized on August 21, 2003 at CIAH, Bikaner.

August 21, 2003 at CIAH, Bikaner.

Dr. R.S. Singh

A lecture on "Fruit cultivation in Arid region" delivered in "Farmers and state officials Training Programme held at CIAH, Bikaner on 21.08.2003.

Dr. B.G.Bagle

Delivered a talk on development of Horticulture in watershed management at CSWRI, Vasad on 25.5.2003.

Dr. V.Lenin

Delivered a lecture on "Dryland Horticulture" to 72 farm women in the training programme organized by SWA-SHAKTI project, G.W.E.D.C.L., in K.V.K., G.A.U., Devgadh Baria, Dahod district, Gujarat, 25.06.2003.

Delivered talks on "C.H.E.S. and its activities" in farmers meeting organized by KRIBHCO, in Saganpura village, Panchmahals district, Gujarat, 27.06.2003.

Sh. S.Raja

Delivered a lecture on " Sustainable vegetable production to ensure Nutritional security to tribal farmers" to 72 farm women trainees at Krishi Vigyan Kendra, Gujarat Agricultural University,Devgadh Baria,Dahod district,Gujarat organized by SWA-SHAKTI project, Gujarat Women Economic Development Corporation Limited on 25.06.2003.

Dr. Sanjay Singh

Delivered a talk on fruit cultivation in semi-arid region in farmers meeting organized by KRIBHCO, in Saganpura village, Panchmahals district, Gujarat, 27.06.2003

.Dr. S.S. Hiwale

Fruit tree based agro forestry system for the semi arid area of Wester India. Special seminar delivered at World Agroforestry Centre, Nairobi, Kenya on 25th July 2003.

Delivered a lecture on "Horticulture development in Watershed Projects" in training programme on, "Watershed Management" to Watershed Development Teem (WDT) members" held at Central Soil and Water Conservation Research & Training Institute at Vasad Centre on 9th March, 2004.

Human Resource Development

Training programme attended

Dr. B.D. Sharma

- Attended winter school on `Role of Nutrients in Sustainable Crop Production.' Organized by Centre for Advance Studies in Plant Physiology. N.D. University of Agriculture & Technology, Kumarganj. Faizabad during 3-23rd December, 2003.

Dr. D.K.Samadia

- ICAR Sponsored National Training Programme on "Protected Cultivation of Horticultural Crops: Centre for advance studies in horticulture, Department of Horticulture, MPKV, Rahuri (Maharastra).March 10 to 30, 2003. (21 days).

- ICAR Sponsored Winter School on "Exploitation of underutilized horticultural crops Department of Horticulture, Rajasthan College of Agriculture; MPUA&T :Udaipur (Rajasthan). November 5 to 25, 2003 (21 days)

Dr. Arun Kumar Shukla

- Attended a summer school on Recent Advances on Agricultural Research Project Management from 9-29 April 2003 at NAARM, Hyderabad.

Dr. R.S. Singh

- Attended Winter School on "Exploitation of under utilized Horticultural Crops", at Deptt. of Horticulture, RCA, M.P.U.A& T, Udaipur, Rajasthan w.e.f. 05.11.2003 to 25.11.2003.

Dr. P. Nallathambi

- Attended winter school on Biotechnological approaches for the management of plant pathogens in export oriented horticultural crops organized by ICAR, New Delhi and TNAU, Coimbatore on 2nd to 22nd December, 2003.

Dr. I.S.Singh

- Attended short course training programme on "Recent Trends in Organic Production of Horticultural Crops" at CISH, Lucknow from 26th May to 4th June, 2003.

- Completed 77th FOCARS training successfully at NAARM, Hyderabad during October 28th to February 24th, 2004.

Dr. V.Lenin

- Attended twenty-one days ICAR sponsored winter school from Oct. 28 to Nov.17, 2003 on "Extension Strategies for Human Resource Development in the Context of Globalization of Agriculture" organized by Department of Agricultural Extension Education, College of Agriculture, University of Agricultural Sciences, Dharwad, Karnataka.

Dr. A.K. Singh

- Participated in short course, Recent trends in organic production of horticultural crops, held at CISH, Lucknow from 26th May to 4th June, 2003

Meeting /Seminars/Symposium/Workshop

Scientiest participated		Name of Meeting/Seminar/Symposium
Dr. D.K. Samadia, Sci. S.S. (Hort.)	-	Attended, National seminar on diversification of agriculture through horticultural crops. February 21-23, 2004 Karnal (India)..Presentation of research paper entitled "Collecting genetic variability in gourd cucurbits from tribal areas of Rajasthan and Gujarat.
	-	Attended, Vth National workshop " NATP sub project on sustainable management of plant bio-diversity, March 17-18, 2004 NBPGR, Zew Delhi.
	-	Attended, XXI Group Meeting on AICRP on vegetable crops, 25-28 May 2003. GAU Campus Anand.
Dr. B.D. Sharma, Sr. Sci. (Soil Sci.)	-	National seminar on Production & Utilization of Aonla at Salem (TN) during 8-10th August, 2003
	-	National Symposium on Organic farming in Horticulture for Sustainable Production held at CISH, Lucknow during August 29-30, 2003.
	-	National Conference on Organic farming for Sustainable Production held NAAS campus, New Delhi during 23-25th March, 2004
	-	Regional training Workshop on Soil Testing for Integrated Nutrient Management at RAU, Bikaner during October 14-15, 2003.
	-	Seventh International Conference on Desert Technology held at Umaid Bhawan Place, Jodhpur. India during 9-14th November, 2003
Dr. R.S.Singh, Sci. S.G. (Hort.)	-	Attended Ist meeting of Informal Support Group, Maru

		Gochar Yojana, Govt of India, at DRDA Hall, Jodhpur on May 24,2003 and IInd meeting of Maru Gochar Yojana at AFRI, Jodhpur on 18.7.2003.
	-	Attended a Seminar on Forage research and development in
	-	Rajasthan, held at ASC-DEC, RAU, Bikaner 6-7 August, 2003.
	-	Attended meeting of Nagar Raj Bhasa Karyanavan Samiti, Bikaner at DR M office, Bikaner on 30.12.2003.
Dr. P.L. Saroj, Sr. Sci. (Hort.)	-	Attended and presented two lead papers in National Seminar on "Production and utilization of aonla" held at Salem, Tamil Nadu, from 8-10 August, 2003.
	-	Attended National Symposium on "Agroforestry and Sustainable Production" held at IGFRI, Jhansi from 7-9 November 2003.
	-	Attended Seminar on 'Organic food products-Prospects of production and trade in arid region" held at IABM, RAU Bikaner on 27th Feb. 2004.
	-	Attended NATP workshop of the project "Develop sustainable agri-silvi-horti. Production system for marginal lands under arid conditions" held at GAU, S.K.Nagar (Gujarat) on dt. 29th December, 2003.
Dr. P. Nallathambi, Sr. Sci.	-	Dr.P.Nallathambi has attended and presented research papers in the 6th International workshop on Plant Growth Promoting Rhizobacteria (PGPR) organized by Auburn University, USA, ICAR and Indian Institute of Spices Research, Calicut., on 5-10th October,2003.
Dr. A. Nagraja, Sci. (PHT)	-	Attended National Workshop cum Hindi training organized by NAARM, Hyderabad during Jan. 27-31, 2004.
Dr. O.P. Awasthi, Sr. Sci. (Hort.)	-	*Horti-Pastoral systems for Arid and semi-arid conditions. Paper presented in National Seminar on "Forage Research and Development in Rajasthan" Organised by Rajasthan Agricultural University, Bikaner from 6-7 August 2003.*
	-	Comparative performance of organic mulches in brinjal (*Solanum melongena*) grown in aonla based cropping system. *Paper presented in National Symposium on Organic Farming in Horticulture for Sustainable*

		Production, organized by Central Institute for Subtropical Horticulture, Lucknow from 29-30 August, 2003.
	-	Crop Diversification for sustainable production in irrigated hot arid eco-system of Rajasthan. Paper presented by the third author (Oral presentation) in seventh International Conference on Desert Technology at Jodhpur from Novemner 9-14, 2003.
	-	Indigenous Medicinal Fruit Plants of the Thar Desert. Paper presented by the second author in Published in National Seminar on New Perspectives in Spices, Medicinal and Aromatic Plants, organized by Indian society for Spices and ICAR Research Complex for Goa from 27-29 November 2003 at Goa.
Dr. I.S. Singh, Sci. (SWC)	-	Effect of organic mulching on leaf nutrient status of eggplant. In. National Symposium on Organic Farming in Horticulture for Sustainable Production. 29-30 Aug., 2003 at CISH, Lucknow.
Dr. Arun. K. Shukla, Sci.	-	Attended a National Symposium on Agroforestry and Sustainable Production from 7-9 November 2003 at IGFRI, Jhansi.
Dr. Anil K. Shukla, Sci.	-	Attended a National Symposium on crop production under changing environment at BCKV, Kalayani West Bengal.
Dr. B.G. Bagle, P.S.	-	Awareness knowledge of tribals about Horticulture. Paper was presented in International Conference on Agricultural policies and strategies for profitable farming and field realities needed reforms and interventions during 5-7th December, held at GAU, Anand.
	-	National Symposium on organic farming in Horticulture for sustainable production, held at CISH ,Lucknow during 29-30th
	-	Attended an International Conference on Agricultural Policies and Strategies for profitable farming: Field realities, Needed reforms and interventions, held at G.A.U., Anand during 5-7th December, 2003.
	-	Attended IIIrd Workshop of JVG-NATP-HFNS at NBPGR, New Delhi, March 23-24, 2003.

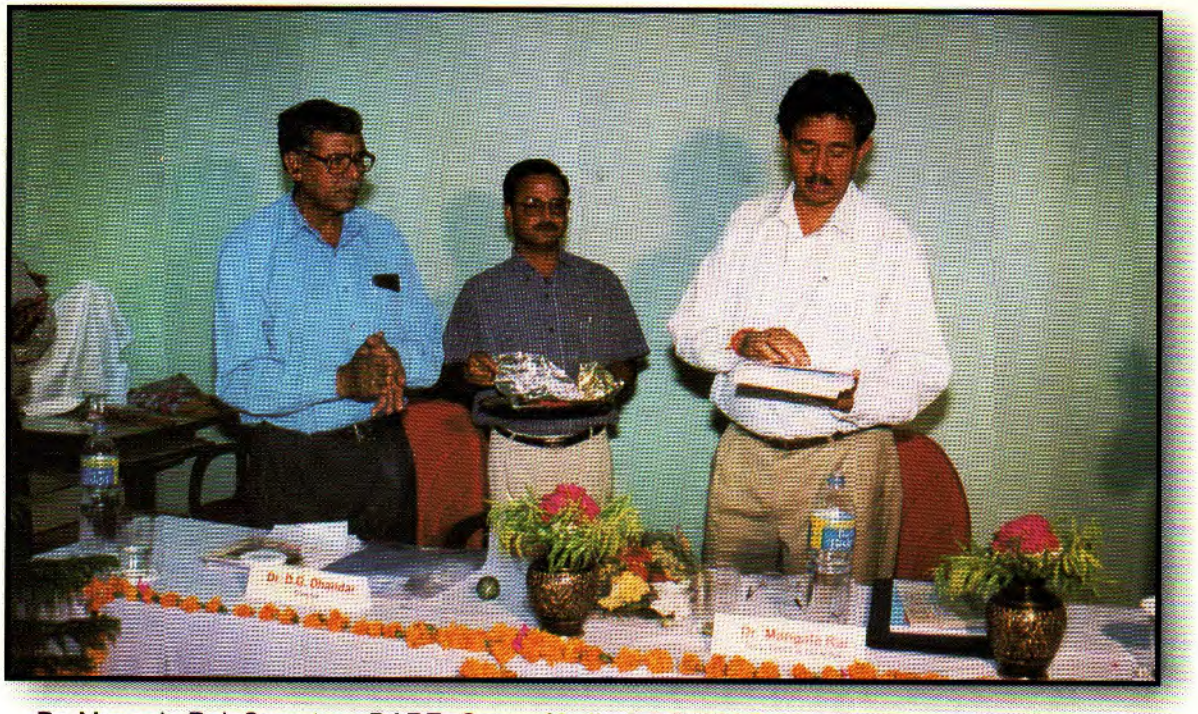
	-	Attended Group Meeting of Programme 2 Horticulture and Vegetable Gardening for Food and Nutritional Security in tribal, backward and hilly areas and integration of two or more programmes at selected locations held at HARP,Ranchi, 9-10th June, 2003.
Dr. Sanjay Singh, Sr. Sci.	-	Participated in National seminar on mango: challenges in management of production, post harvest processing and marketing held at GAU, Junagadh, 14-15, June, 2003.
Dr. A.K. Singh, Sci.	-	Participated in National Conference on organic farming for sustainable production, held at NASC, New Delhi, March 23-25,2003.
Dr. S. Raja, Sci.	-	Participated the National symposium on Harnessing Heterosis in crop plants held at Indian Institute of Vegetable Research, Varanasi, March 13-15,2004.

Transfer

- Dr. B.B.Vashishtha, Principal Scientist (Hort.) tranferred from CIAH, Bikaner to NRCSS, Tabiji, Ajmer as Acting Director.
- Dr. D.B.Singh, Sr. Scientist (Hort.) transferred from CIAH, Bikaner to CIPHET, Abohar.

Dr. Mangala Rai, Secretary, DARE, Govt. of India & DG, ICAR, New Delhi inaugurating metrology station at CIAH, Bikaner on 11th April 2003

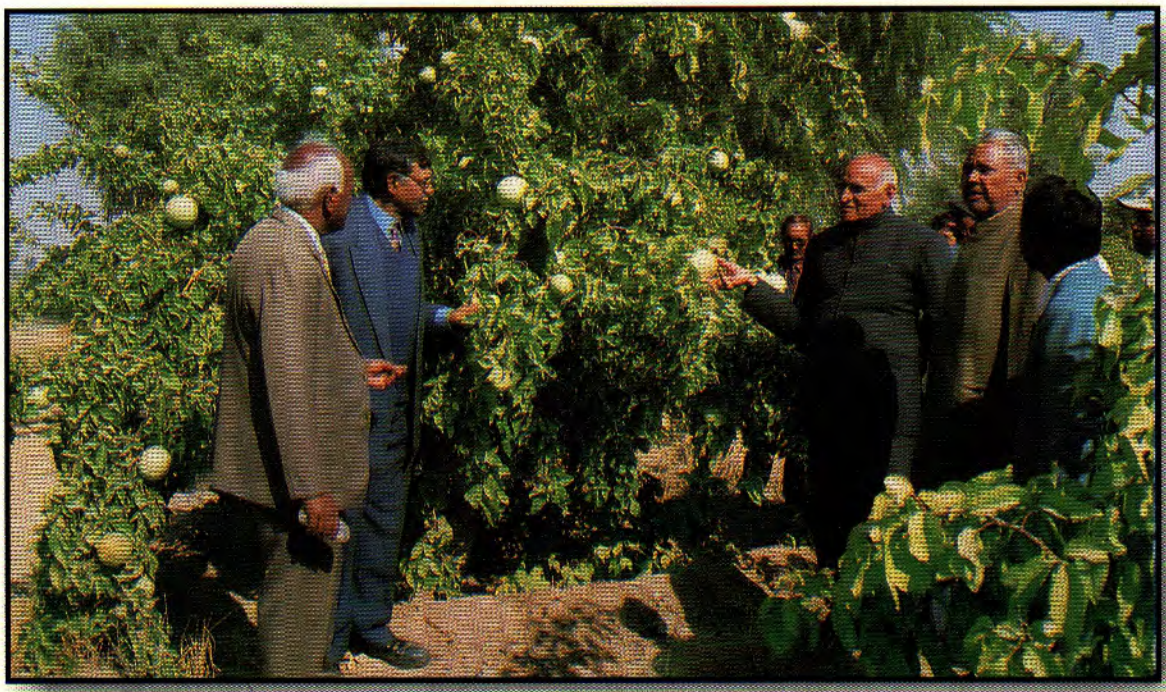
Dr. Mangala Rai, Secretary, DARE, Govt. of India & DG, ICAR, New Delhi discussing field experiments with Scientists of the Institute



Dr. Mangala Rai, Secretary, DARE, Govt. of India & DG, ICAR, New Delhi releasing the book

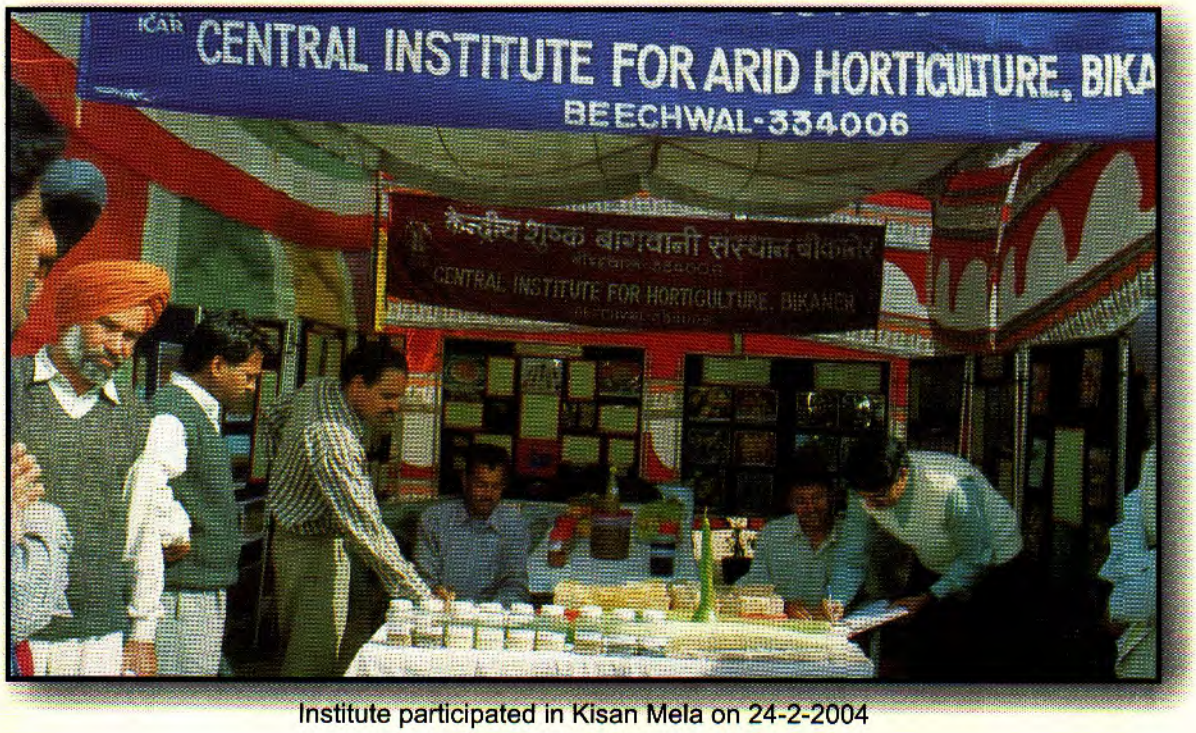
Dr. A.S. Faroda, Chairman, ASRB, New Delhi, inaugurated sale counter of Institute

Dr. A.S. Faroda, Chairman, ASRB, New Delhi, discussing experiments in field about aonla



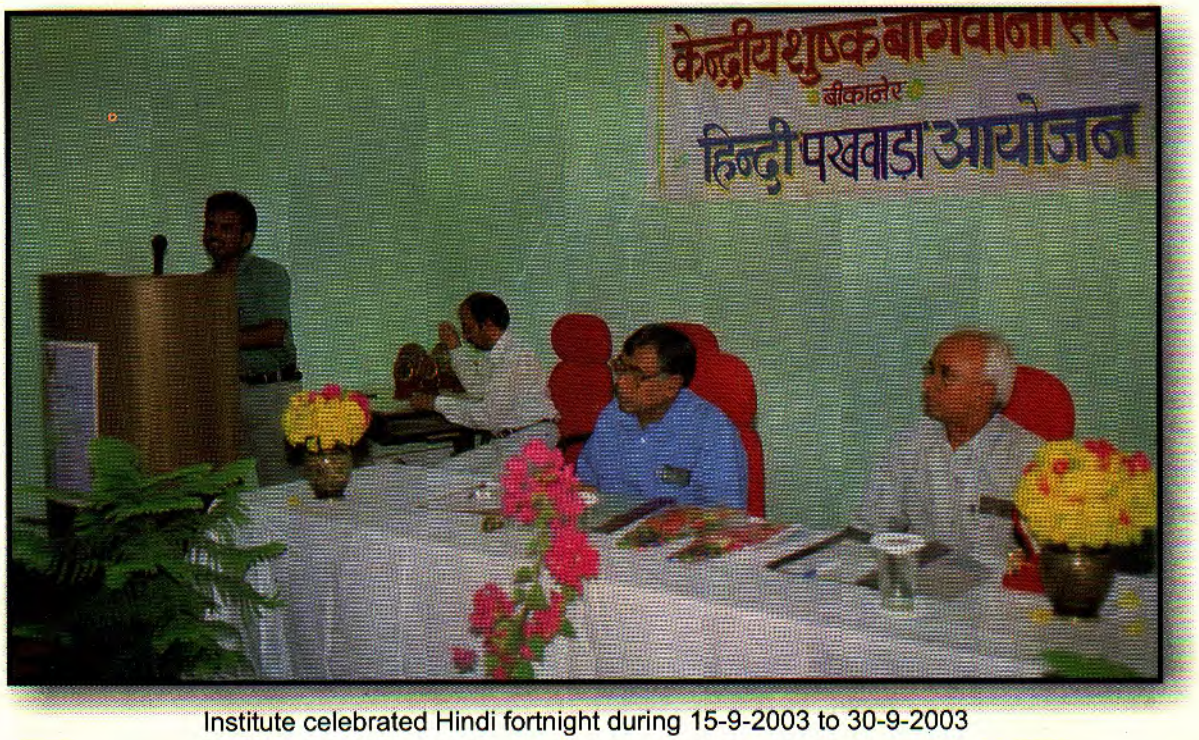
Dr. A.S. Faroda, Chairman, ASRB, New Delhi, discussing experiments in field about Bael

IMC meeting of Institute



Institute participated in Kisan Mela on 24-2-2004

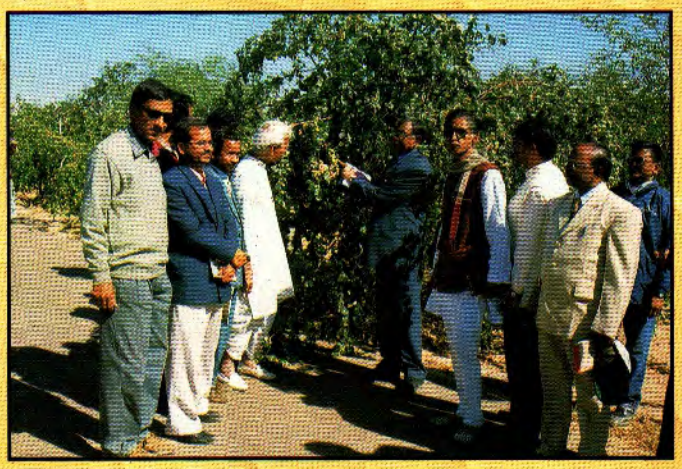
Institute celebrated aonla day on 9-12-2003



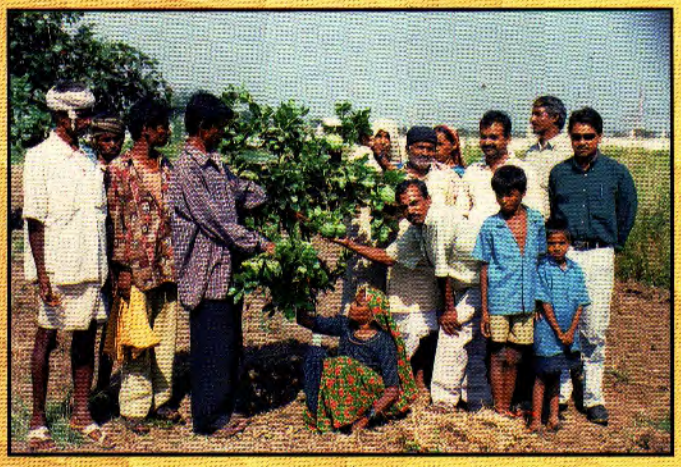
Institute celebrated Hindi fortnight during 15-9-2003 to 30-9-2003

Extension initiatives at CIAH, Bikaner and CHES, Godhra

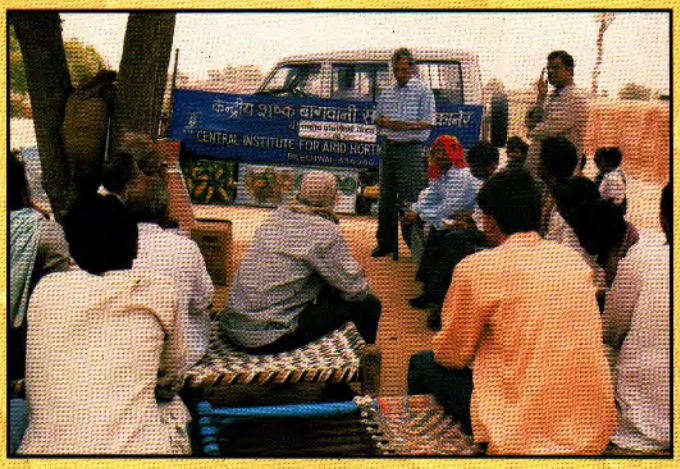
Demonstration



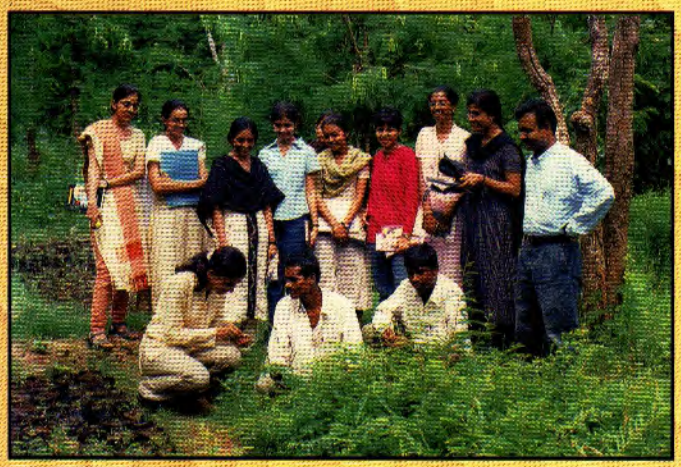
Press Conference



On Campus Farmers Training



Off Campus Farmers Training



Training for Farm Women

Participation in Kissan Mela