Annual Report
वार्षिक प्रतिवेदन
2010-11

भाकृअनुप
ICAR

National Research Centre on Seed Spices

Tabiji, Ajmer-305 206 (Rajasthan) INDIA

Annual Report
वार्षिक प्रतिवेदन
2010-11

National Research Centre on Seed Spices
Tabiji, Ajmer-305 206 (Rajasthan) INDIA

Correct Citation:
Annual Report 2010-2011 National Research Centre on Seed Spices

Chief Editor : Dr. R. K. Kakani
Senior Scientist (Plant Breeding)

Editors : Dr. O. P. Aishwath
Senior Scientist (Soil Science)

Dr. S. N. Saxena
Senior Scientist (Plant Physiology)

Dr. Y. K. Sharma
Senior Scientist (Plant Pathology)

Dr. Krishna Kant
Senior Scientist (Entomology)

Sh. Mukesh Vishal
Scientist (Ag. Statistics)

Cover Page bv : Dr. R.K. Solanki
Scientist (Plant Breeding)

Photographs by : Sh. M.A. Khan (T-6) and Sh. G. K. Tripathi (T-3)

Published by :
Dr. M.M. Anwer,
Director
National Research Centre on Seed Spices
Tabiji, Ajmer-305 206, Rajasthan, India
Phone:#91-145-2681001
Telefax :#91-145-2443238
E-mail : mmanwer@nrcss.ernet.in

Printed at:
JOB Offset Printers, Ajmer
Ph. : 9829472031

Copies: 100

NRCSS Annual Report 2010-11

CONTENTS

NRCSS Annual Report 2010-11

PREFACE

India has been known as a land of spices since time immemorial. The country's ability to grow and use spices has attracted the peoples of all lands to India in a quest for its unique spices. We are the largest producers, consumers and exporters of spices in the world. India produces a total of 5.6 lakh tonnes seed spices every year. Ninety percent of these spices are consumed within the country and the rest 10% is exported to various countries of the world. India's export caters to 50% of the world demand of spices. The global demand is poised to increase 10 fold in the next 5 years. This is an opportunity that the country fail to capitalize upon in order to meet this increased global demand. The country needs to double its spices production in the next 5 years. This can only be achieved by increasing the area of cultivation and productivity of spice crops. In order to do this there is a need for intensification of research in seed spices in order to develop new varieties, better production technologies and improved protection practices for the biotic and abiotic stresses. We need to have new varieties of crops with higher productivity, enhanced quality, shorter duration and better resistance to pest and diseases. These varieties will not only show increased productivity but will also have the capacity to fit into the existing cropping system and crop rotation pattern as an additional crop so that we are able to reap bumper harvest from the same area of land at the same quantity of water. We also need to develop advanced production technologies for increasing the yield and quality of spices by various modern methods such as protected cultivation, increased mechanisation, improved nutrition and water utilization.

The consumers of spices have the most exacting standards of product purity. The residual toxicity of inorganic pesticides and fungicides is now been measured in ppb. The challenge therefore is to develop a region of organic plant protection for successful cultivation of spices. All these activities have to be supported by effective basic and strategic research in which science may play a larger role in the assured cultivation of spices. It is also important that all the technologies developed in the research station reach the farmer's field through effective transfer of technology and the farmers also need to get good returns for their production. Systems need to be developed for contract cultivation, better marketing and onfarm value addition to the spice crops.

The NRCSS is gearing up in all these areas and is diligently working to bring the blessing and advantages of science to the doorsteps of the poorest of the poor small farmers who were toiling in the hot deserts of Rajasthan and Gujarat to produce seed spices which are the nature's most valuable gift to the humankind.

The Annual Report is the saga of these existing events that are unfolding at NRCSS in Ajmer.

Ajmer
July, 7, 2011

(M.M. Anwer)
Director

NRCSS Annual Report 2010-11

1. EXECUTIVE SUMMARY

The National Research Centre on Seed Spices is a sole centre of Indian Council of Agricultural Research working on improvement of seed spices for the last one decade. The mandate of the Institute is to carry out basic, applied and strategic research for the improvement of seed spice crops for Indian farmers. The whole research activity is carried out in coordination with five major scientific sections of the Institute: Crop Improvement, Crop Production, Crop Protection, Basic Science and Social Science.

Research Achievements

The outstanding research findings are summarized here for each section:

Crop Improvement:

- Total 1578 accessions of ten seed spice crops are being maintained at the NRC on Seed Spices, Ajmer for facilitating their utilization in breeding programme. Out of the total collections maintained, 1495 are indigenous and 83 are exotic collections. The enhancement of genetic resources of seed spices crops was done by adding 58 indigenous and 54 exotic lines of fenugreek (procured from ICARDA, Syria) during 2009-10
- The total assemblage of germplasm comprised of active germplasm of 1297 accessions of major seed spices (Corinader, Cumin, Fennel and Fenugreek) and 279 accessions of minor seed spices (Ajowan, Dill, Nigella, Anise, Celery and Caraway)
- Multilocation evaluation of germplasm was done for coriander, fenugreek, fennel and dill
- From a population of M3 generation of UM-344 fenugreek variety a mutant A3-45-7 is selected showing only 27.5 % disease incidence of powdery mildew
- In coriander a genotype MSKM 1059 is found to be promising with respect to check variety RCr-425 and ACr-1. Composite gene pools have been developed and advanced to fourth generation in coriander for early maturity coupled with high yield; small seed size and four basal leaves, medium height, high number of seeds per umbel and high yield.
- In fennel dwarf genotype AF-87 was found best against check. Other medium height genotypes AF-01-30-1 and AF-05-2 were also found best for seed yield.
- Cumin germplasm was screened and accessions found superior for seed yield were JC-2000-20, JC-99-37, JC-2000-23 and JC-96-36 than the checks GC-4 and RZ-19.
- In celery three accessions Cel-08 , Acel-2 and Acel-6 were found superior for seed yield than the local heck and Acel-1
- In dill five entries AD-01-4, AD-S-11, AD-S-01-3, AD-S-01-4 and AD-S-01-28 out yielded the best check AD-2
- In ajwain early genotypes have been identified which will be re-evaluated for the stable expression of the trait
- Molecular characterization of 17 released of fenugreek has been done using RAPD technique and by detecting polymorphic rDNA sites. Studies on molecular diversity is under progress on other 41 varieties of other seed spices crops viz., cumin (6), coriander (13) and fennel (13)

Crop Production:

- For Nutrient Influx Efficiency in *Coriandrum sativum*, *Cuminum cyminum, Foeniculum vulgare* and *Trigonella foenugraecum*

cultivars, roots were active at different stages for different cultivars, which shows that nutrient uptake and revoal of crop differs with varieties.

- IW:CP ratio 0.6 is optimum for coriander. Higher addition of irrigation water leads to fast mineralization of organic matter.
- Seed produced by the Ajmer coriander-1 was 5-6 time lower with the alkaline pH then the neutral to mild acid pH. Harvest index was at par with pH acid to neutral pH and was lowest at pH 7.5.
- It is inferred that insect proof net tunnel with low pressure drip irrigation is better for higher growth and yield with a minimum incidence of disease and aphids in cumin whereas plastic walk tunnel with low pressure drip irrigation is better for cumin.
- Plastic walk in tunnel with low pressure drip recorded highest seed yield (1689 kg/ha) in coriander. For off season coriander crop green net exhibited best results with respect to seed germination, growth, yield and yield attributes.
- Among the seed spices the fennel resulted significantly highest seed yield (1575.49kg/ ha.), stover yield (2665.28 kg/ha) and biological yield (4240.77 kg/ha) over other seed spices followed by ajowan.
- Sowing of anise on 1st November with crop geometry of 30 x 10 cm, dill on 15th October with crop geometry of 40 x 20 cm and nigella on 15th October with crop geometry of 25 x 10 cm exhibited the highest seed yield.
- Yield of fennel increased with the application 5 and 10t/ha vermicomposts of various crop residues. The seed yield with fennel VC and mixed VC were at par either applied 5 or 10 t/ha.

Crop Protection:

- Field surveys of seed spices crops revealed that blight (0-70%), wilt (0-28%) and powdery mildew (20-54%) in cumin; stem gall (10-62%) and powdery mildew (0-75%) in coriander; powdery mildew (0-96%) in fenugreek and gummosis and powdery mildew (22-95%) diseases in fennel were prevalent in major growing areas surveyed in Rajasthan, U.P. and Gujarat. The phanorogamic plants i.e. *Orobanche sp.* and *Cuscutta sp.* were also observed in cumin fields in Nagaur district.
- In cumin, wilt disease was observed from early crop stage. The other diseases observed were blight and powdery mildew. Blight was appeared during the month of January at pre flowering to flowering stage, where as powdery mildew was appeared late in the season at the maturity stage of the crop.
- In fenugreek powdery mildew disease was observed in the month of February and the disease was spread within the field up to maturity stage of the crop (mean disease index 42-51%). The root rot of fenugreek was observed in early growth stage of crop.
- In coriander, powdery mildew symptoms were observed during late in the season and spread within a week after initiation. Mean disease index was 59-87% in different dates of planting.
- In other seed spice crops; wilt, powdery mildew and blight in dill, root rot, leaf spot and powdery mildew in anise, root rot in nigella were reported.
- Reduction in the disease and increase in seed yield of cumin was observed with the application of *Trichoderma viride* applied as seed treatment and soil application.
- Maximum reduction in wilt disease incidence and increase in seed yield was observed with the application of mustard residue + mustard cake + neem cake followed by mustard residue + mustard cake + poultry manure (32.7%). However, all organic amendments reduced the wilt incidence as compared to untreated control (61.1%).
- Maximum disease and pest reduction and increase in yield in cumin was observed with application schedule S_2 & S_3 (Soil application of Neem cake + Mustard cake, Seed treatment with Tebucanazole, Soil drenching with metalaxyl, foliar spray with mancozeb, propiconazole, karathane, Acetamiprid and Imidachlorpid).
- Application of botanicals neem oil @ 2% and imidachlorprid 0.005% and thiomethoxam - 0.025% proved most effective insecticides against midge control in coriander crop under field application. Late shown crop was also shown low infestation of the pest.
- Sucking pests comprises most of insect pests complex of seed spices. Among natural enemies complex predators coccinellids, syrphid fly and *chrysoperla carnea* and parasitoides *Aphidius* spp. Commonly found during full vegetative stages to crop maturation stages
- Cigarette beetle (*Lasioderma serricorne* L.) was found most serious pests of storage .
- For Management of aphids in cumin and fennel crop, application of *Verticillium lacanii, Beauveria bassiana* and Allyl iso thio cyanate gives maximum protection and yield after insecticidal check.

Basic Science:

- In the study to identify physiological parameters and their relation with seed yield it was observed that rate of photosynthesis in two genotypes in all seed spices varies significantly at all growth stages, PAR was highly variable at different stages which have direct relation with rate of photosynthesis, Difference between leaf to air temperature was significant in all crops at all stages and A high ratio of SW/RW and FW/DW Coriander and cumin resulted in to higher yield.
- Spray of ABA, ASA, Betain hydrochloride and proline showed that concentration of some chemicals on growth and yield of cumin and coriander was significant and membrane integrity was also affected by spraying these chemicals.
- Water stress had effected morpho-physiological and seed quality parameters including total oil, essential oil, test weight and seed size. All recorded parameters showed significant genotypic variation as well as significant interaction of genotype with environment. Midterm water stress did not showed adverse effect on studied quality parameters while terminal water stresses exhibited reduction in most of the accessions.

Social Science:

- In transfer of technology, 16 training programmes were organised in three districts namely Ajmer, Jodhpur and Baran, in which total 1235 farmers were benefitted. Besides this, 432 demonstrations of cumin and coriander were conducted where 62 to 65 percent increase in cumin and 18 percent increase in coriander was observed.
- State wise list have been prepared for 200 seed spices traders/ industrialists and exporters in MS-access programme tables and interlinked with each other.
- Development of seed spice expert system is in progress and varieties and disease module has been developed

Seed Production:

- Seven seed spices crops namely coriander, cumin, fennel, fenugreek, ajowain, dill and nigella have been taken and 1225 kg seed was produced for these crops.

NRCSS Annual Report 2010-11

2. कार्यकारी सारांश

राष्ट्रीय बीजीय मसाला अनुसंधान केन्द्र, भारतीय कृषि अनुसंधान कृषि परिषद का एक संस्थान है जो पिछले 10 वर्षों से बीजीय मसालों के समस्त पहलुओं पर अनुसंधान कार्य में सक्रिय रूप से सलंग्न है। बीजीय मसालों का उत्पादन, उत्पादकता व गुणवत्ता वृद्धि के लिए संस्थान के मुख्य अनुसंधान कार्य का समन्वय पाँच अनुभागों द्वारा संचालित है। ये अनुभाग फसल सुधार, फसल उत्पादन, पादप संरक्षण, मूल विज्ञान तथा सामाजिक विज्ञान है।

अनुसंधान उपलब्धियाँ :

विभिन्न अनुभागों में किये गये महत्त्वपूर्ण अनुसंधान एवं प्रसार कार्य की उपलब्धियाँ निम्नलिखित है :–

फसल सुधार

- वर्ष 2009–10 के अन्तर्गत 58 देशी व 54 विदेशी मूल के आनुवांशिक संसाधनों को एकत्रित किया गया हैं। इस समय दस बीजीय मसालों के 1578 जननद्रव्यों को संस्थानम ंस रंक्षित कियाग याह ैजिसमेंस े1 495 जनन द्रव्य देशी व 83 विदेशी मूल से एकत्रित किये गये हैं। इन जनन द्रव्यों में 1297 जनन द्रव्य मुख्य बीजीय मसाले – धनिया, जीरा, सौंफ व मैथी के हैं। सौंवा, कलौंजी, विलायती सौंफ, सेलेरी तथा काले जीरे के हैं।
- धनिया, मैथी, सौंफ तथा सौंआ के जनन द्रव्यों को देश के विभिन्न स्थानों पर क्षेत्रीय मूल्यांकन किया गया।
- चूर्णित आसिता रोग के विपरीत प्रजनन हेतु मैथी की किस्मय ू.एम.3 44f कस्मक ीए म.3स ंतिम ंए क उत्परिवर्तित वंशज ए. 3–45–7 का वरण किया गया, जो 27.5% रोगरोधिता दर्शाता है।
- धनियेक े ज ननद ्व्यए म.के.एस.के.एम.–1059क ा तुलनात्मक अध्ययन उपलग्ध किस्म आर.सी.आर.–425 तथा ए.सी.–1 से करने पर उन्नत पाया गया। चौथी संतति में जल्दी परिपक्वता लाने, अधिक उत्पादन, छोटे बीज, मध्यम उँचाई इत्यादि गुणों की एक किस्म में संगहित करने हेतु संयुक्त जीन समूह का समावेश किया गया।
- सौंफ के बौने जनन द्रव्य ए.एफ.–87 की तुलना उपलब्ध प्रजाति से करने पर उन्नत पाया गया। अन्य मध्यम ऊँचाई वाले जनन द्रव्य–ए.एफ.–01–30–1 और ए.एफ.–05–2 भी उन्नत पाये गये।
- अधिक उत्पादन हेतु जीरे के जनन द्रव्य जे.सी.–2000–20, जे.सी.–99–37, जे.सी.–2000–23 तथा जे.सी.–4 तथा आर.जेड.–19 के साथ किया गया तथा उन्नत जनन द्रव्य का चयप किया गया।
- सेलरी के जनन द्रव्यों में सेल.–08, एसेल.–2 तथा एसेल–6 की तुलना उपलब्ध क्षेत्रीय किस्म एसेल.–1 से करने पर उत्तम पाये गये।
- सौंवा की उपलब्ध किस्म ए.डी.–2 के साथ पाँच नवीन जनन द्रव्यों की तुलना में निम्नलिखित उत्तम पाये गये –
- ए.डी.–01–4,ए .डी.–एस.–11,ए .डी.–एस.–01–03, ए.डी.–एस.01–4 तथा ए.डी.–एस.–01–281।
- अजवायन में अगेती गुण दर्शाने वाले जनन द्रव्य की पहचान की गई। इसके गुण में स्थायित्व लाने के लिए पुर्नमूल्यांकन किया जायेगा।
- मैथी की 17 किस्मों का आण्विक लक्षणात्मक अध्ययन आर.ए.पी.डी. तकनीकी तथा पॉलीमोर्फिक आर.डी.एन.ए. स्थानों द्वारा लक्षणात्मक अध्ययन किया गया। इस अध्ययन में बीजीय मसालों के अन्तर्गत विविधता का अध्ययन किया गया, जिसमें जीरा के 6, धनिये के 13 तथा सौंफ के 13 जनन द्रव्य सम्मिलित थे।

फसल उत्पादन :

- धनिया, जीरा, मैथी तथा सौंफ की किस्मों द्वारा पौषक तत्वों की ग्रहण करने की मात्रा का अध्ययन किया गया साथ ही बीजीय मसालों के विभिन्न भागों में संचित पौषक तत्वों का आंकलन किया गया।

- धनियें की उचित उपज लेने के लिए आई.डब्ल्यू.: सी.पी.ई. अनुपात 0.6 उपयुक्त पाया गया तथा अधिक सिंचाई काल की मात्रा तीव्र गति से खनिजीकरण के परिणामस्वरूप मृदा में जैविक कार्बन की मात्रा कम हो जाती है।
- धनिये का मूल्यांकन हल्की अमलीय मृदा से लेकर मध्यम क्षारीय मृदा में किया गया तथा क्षारीय मृदाओं में हल्की अमलीय मृदा की तुलना में 5 से 6 गुना वृद्धि एवं उत्पादन प्रभावित होता है। अंसतुलित वृद्धि तथा उचित बीज बनने के कारण कटाई नियतांक पी.एच. 7.5 पर सर्वाधिक था।
- जीरे में कीट रोधी, सुरक्षित फसल उत्पादन के अन्तर्गत प्रवेश रहित कीट जाल की सुरंग के साथ कम दबाव वालीब ूंद–बूंद ंसंचाईक े प रिणामस र्वोत्तमप ्रा1ह ुए। साथ ही जीरे में कम से कम कीट तथा बीमारियों का प्रकोप हुआ।
- अन्त: सस्य के अन्तर्गत बीजीय मसालों को फलदार वृक्षों केस ाथउ गानेप रस ौंफक ाउ त्पादनस र्वाधिकथ ा। तदोपरान्त सर्वाधिक उत्पादन अजवायन का था।
- विलायती सौंफ की बुवाई 1 नवम्बर तथा पौधे से पंक्ति की दूरी 10×30 से.मी. तथा कलौंजी में बुवाई 15 अक्टूबर तथा पौधे एवं पंक्ति की दूरी 20×40 से.मी. रखने पर सर्वाधिक उपज प्राप्त हुई।
- विविध फसल अवशेषों से निर्मित केंचुए की खाद का प्रयोग 5 से 10 टन की दर से सौंफ में प्रयोग करने पर 21 से 35% अधिक बीज उत्पादन हुआ।
- संरक्षित फसल उत्पादन के अन्तर्गत प्लास्टिक की ऊँची सुरंगों में कम दबाव वाली बूंद–बूंद की सिंचाई से सर्वाधिक उपज प्राप्त हुई। इसी प्रकार ग्रीष्म एवं वर्षा ऋतु में हरे जाल में सर्वोत्तम परिणाम प्राप्त हुए।

फसल संरक्षण :

- बीजीय मसालों में बीमारियों के सर्वेक्षण से जीरे में 0 से 70% झुलसा, 0 से 28% उखटा तथा 20 से 54% चुर्णित आसिता। रोग का प्रकोप पाया गया। धनिये में चूर्णिल आसिता 0 से 75% तथा स्टेम गाल 10 से 62% पाया गया। मैथी में चूर्णिल आसिता 0 से 96% पाई गई। सौंफ में चूर्णिल आसिता 22 से 95% था। जीरे में ओरेवेन्की तथा अमरबेल को परजीवी के रूप में पाया गया।
- जीरे में उखटा रोग के लक्षण आरंभ में दिखाई दिये तथा अंगमारी रोग के लक्षण फूल आने से पूर्व देखे गये तथा चूर्णिल आसिता के लक्षण परिपक्व अवस्था में दिखाई दिये।
- मैथी में चूर्णिल आसिता का प्रकोप फरवरी से आरंभ होकर परिपक्व अवस्था तक था तथा जड़–गलन फसल की आरम्भिक अवस्था में दिखाई दिया।
- धनिये में चूर्णिल आसिता के लक्षण फसल की परिपक्व अवस्था के समय दिखाई दिये। जिनका रोग नियतांक 59 से 87% था।
- ट्राइकोडर्मा विरिडी के प्रयोग से जीरे में रोगों का प्रकोप कम हुआ तथा फसल के उत्पादन में वृद्धि हुई।
- जीरे में सरसों के फसल अवशेष+सरसों की खली+नीम की खली के प्रयोग से उखटा रोग का प्रकोप कम हुआ तथा उत्पादन में वृद्धि आंकी गयी। अन्य जैविक उपचारों के परिणाम सार्थक थे।
- कीट एवं रोग नियंत्रण के लिए जैविक व रासायनिक नियंत्रकों का अनुसूची बद्ध प्रयोग किया गया, जिसमें नीम की खली+सरसों की खली, टेबुकोनाजोल से बीजोपचार, मेटालेक्सिल का मृदा प्रयोग, मेन्कोजेब प्रोपिकेनाजोल, केराथेन, एसीटामिप्रिड व इमिडाक्लोपिड का छिड़काव से कीट एवं रोगों का प्रभाव कम हुआ तथा फसल उपज में बढ़ोतरी हुई।
- धनिये में मिज के प्रयोग को कम करने के लिए नीम तेल 2% की दर से इमिडाक्लोरप्रिड़ 0.005% तथा थाइमेथोक्जाम का प्रयोग फसल बोने पर भी इस कीट का प्रकोप कम पाया गया।
- बीजीय मसालों का रस चूसने वाले कीटों के नियंत्रण के लिए परजीवियों में कोक्सिनेलिड़, सिरफिड़ फ्लाई, क्राइसोपेर्ला कार्नेला और पेरासिटोइड्स एफिड्स प्रजाति

मुख्य रूप से फसल वृद्धि के समय से लेकर परिपक्व अवस्था तक उपस्थिति दर्ज की गई।

- बीजीय मसालों में सिगरेट बीटल का प्रकोप भण्डारण के समय सार्थक रूप से हानि पहुँचाता है।
- जीरे तथा सौंफ में माहुँ के नियंत्रण हेतु वर्टीसिलियम लेकेनि, बीयूवेरिया बेसीइना और एलाइल आइसो थायोसाइनेट का प्रयोग प्रभावी पाया गया।

मूल विज्ञान :

- पादप कार्यिकी कारको तथा उनका संबंध बीजोत्पादन पर किया गया और सभी बीजीय मसालों के दो जनन द्रव्यों में प्रकाश संश्लेषण की विविधता पायी गयी तथा प्रकाश के लिये सक्रिय विकिरण की विविधता का सीधा प्रभाव प्रकाश संश्लेषण पर आंका गया। पर्ण तापक्रम तथा वायु तापक्रम में विभिन्न वृद्धि की अवस्थाओं में सार्थक विविधता पाई गई।
- विभिन्न रसायनों जैसे ए.बी.ए., ए.एस.ए., बीटेन हाइड्रोक्लोराइड तथा प्रोलीन के छिड़काव से धनिये तथा जीरे के उत्पादन में तथा कोशिका झिल्ली की सलंग्नता में सार्थक परिणाम प्राप्त हुए।
- मृदा नमी की कमी से धनिये में पादप शरीर एवं कार्यिकी तथा बीज गुणवत्ता जैसे कि तेल, वाष्पशील तेल, बीज का आकार एवं भार प्रभावित हुआ। उपरोक्त समस्त कारक विभिन्न जनन द्रव्यों में भिन्न–भिन्न पाये गये। फसल की मध्यावस्था में मृदा की नमी की कमी का प्रभाव बीज की गुणवत्ता पर अप्रभावी था।

सामाजिक विज्ञान :

- तकनीकी हस्तांतरण के लिये 16 प्रशिक्षण कार्यक्रम अजमेर, जोधपुर एवं बारां जिले में आयोजित किये गये जिसमें 1235 कृषक लाभान्वित हुए। इसके अतिरिक्त धनिये व जीरे के 432 प्रक्षेत्र प्रदर्शन किये गये जिससे 62 से 65% जीरे के उत्पादन में तथा 18% धनिये के उत्पादन में वृद्धि आंकी गई।
- एम.एस. एक्सेस प्रोग्राम द्वारा 200 व्यापारी, उद्योगपति तथा निर्यातकों की राज्य स्तर से लेकर राष्ट्रीय स्तर पर सूची तैयार की गई।
- कृषकों के लिए विशेष्य संगणित प्रोग्राम (एक्सपर्ट सिस्टम) विकसित किया गया, जिसमें किस्मों तथा बीमारियों का मोड्यूल विकसित किया जा चुका है तथा अन्य मोड्यूल्स का कार्य प्रगति पर है।

बीज उत्पादन :

- राष्ट्रीय बीजीय मसाला अनुसंधान केन्द्र द्वारा 1225 किलोग्राम धनियो, जीरा, सौंफ, मैथी, अजवायन, सौंवा तथा कलौंजी का बीज उत्पादन किया गया।

3. INTRODUCTION

The story of Indian spices dates back to 7000 years into the past. The seed spices are a group, which denotes all those annuals whose dried fruit or seeds are used as spice. There are about twenty seed spices are grown in India, the important among them are coriander, cumin, fennel, fenugreek, ajwain, dill, celery, anise, nigella and caraway. Almost all the seed spices are winter season crops (*rabi*) need cool weather conditions for better growth and development. However frost leads to major damage to these crops. Late winter rainfall also adversely affect the quality and quantity of production by infestation of disease, pests etc. The seed spices are aromatic vegetable products of tropical origin and are commonly used in pulverized state, primarily for seasoning or garnishing the foods and beverages. They are also used in preparation of various value added products viz. spice oils, oleoresins and spice powders. Seed spices possess industrial importance and are used in cosmetic, perfumery and various pharmaceutical preparations medicines. The area of cultivation of seed spices in India is 9,22,274 ha and the production is 5,94,120 metric tonnes. India is the largest producer, consumer and exporter of seed spices. India had earned Rs. 5440 millions during 2008-09 by exporting 52,550 tonnes seed spices to various countries. This is all time high both in terms of money and quantity. While, this presents an excellent commercial opportunity for the country, we must remember that there are important competitors waiting in the wings. These countries include Egypt, Iran, Pakistan, Turkey, Iraq, Morocco and Italy. It is thus important that in order to meet this challenge, there must by a quantum jump in the production and productivity of seed spices.

Rajasthan and Gujarat have emerged as "Seed Spice Bowl" and together contribute more than 80 per cent of the total seed spices production in the country. Other important seed spice growing states are Madhya Pradesh, Orissa, Tamil Nadu, Andhra Pradesh, Karnataka, Bihar, Uttar Pradesh, Punjab and West Bengal. India grows about twenty important seed spices. The major among these are coriander, cumin, fennel and fenugreek. Other minor seed spices crops include ajowan, dill, nigella, anise, caraway and celery which are grown in smaller areas in different parts of the country.

3.1 History:

There has been ever increasing demand of seed spices and importing countries look at India as consistent source. In view of the aforesaid importance of seed spices in the country, the Indian Council of Agricultural Research established the National Research Centre on Seed Spices at Ajmer to initiate research work on seed spices especially aimed at improving the productivity and quality with reference to export value and domestic demand. The Indian Planning Commission approved establishment of an independent National Research Centre on Seed Spices (NRCSS) during the IX Five-year Plan and came into being on April, 22, 2000. The site selection committee constituted in 1998 by ICAR, recommended establishment of NRCSS at the site offered by the Government of Rajasthan with 50 acres of land.

3.2 Location and Climate:

The NRCSS is located in Tabiji farm area on the Ajmer-Beawar road 13 km away from railway station in the city. The Ajmer city is well connected by road and railway line to Ahmadabad and Delhi with distance of 516 km and 388 km, respectively in opposite directions. The nearby airport is Jaipur, situated about 125 km away from Ajmer.

The centre lies on 74^0 35' 39" E to 74^0 36' 01" longitude and 26^0 22' 12" to 26^0 22' 31" N latitude at an altitude of 460.17 m above mean sea level. The soil of the research farm is sandy loam, poor in fertility and water holding capacity, having pH 8 to 8.3, EC 0.07 to 0.12 and 0.15 to 0.23% organic carbon, available N 178.5 kg ha-1 (low), P_2O_5 12 kg ha-1 (medium), K_2O 85 kg/ha-1 (low), Ca 214.7 kg ha^{-1} (high), Mg 258 kg ha^{-1} (medium), S 27 kg ha-1 (medium).

The rainfall in the area is highly erratic and more than 90% of the rain is received during July to September with several intermittent long dry spells. The monsoon rains generally commence by the end of June but sometimes delayed till the first week of August. The rainfall is confined to the period mostly between July to September, the rainfall averages between 250-500 mm with a maximum of 750 mm in good rainy years and 50-200 mm in scanty rainy years. The temperature ranges from 2-5^{0}C during January and 42-45^{0}C during May. The winter showers are meagre. Occurrence of drought is frequent. The annual loss through PET is 1566 mm. The occurrence of frost is also observed occasionally, generally after a gap of every 2-3 years. The relative humidity in the district is generally higher than 60% during the monsoon season reaching to as high as 75%, but the annual average humidity is less than 50%. The agro meteorological data for the cropping year for which the results are presented in this report is given in Table 1.

3.3 Mandate:

- To conduct basic and strategic research to enhance production, productivity and quality of seed spices.
- To serve as national repository of seed spices germplasm, relevant information and establishing global gene bank for seed spices.
- To establish relevant institutional linkages nationally and internationally, offer consultancy and training.
- Providing adequate infrastructure for seed spices research, by establishing modern laboratory for analysis of plant, seed produce with export fitness.
- To monitor the adoption of new and existing technologies to make sure that research is targeted to the needs of farming community.

Table 1: Agro meteorological data for the year 2009-10

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Maximum	Minimum	At 8.30	At 17.30	
April, 2009	33.7	24.4	22.3	8.6	1.9
May, 2009	40.4	28.5	32.5	13.5	8.7
June, 2009	39.6	27.7	47.8	26.8	26.2
July, 2009	33.7	25.8	70.7	52.9	131.4
August, 2009	32.9	24.7	69.5	51.5	81.2
Sept., 2009	36.5	25.6	56.4	30.7	29.8
Oct., 2009	33.3	20.8	42.5	21.0	2.5
Nov., 2009	28.4	16.1	50.1	30.6	7.9
Dec., 2009	24.8	12.6	52.8	32.8	0.0
Jan., 2010	24.0	10.3	58.8	25.9	0.6
Feb., 2010	28.4	14.3	44.2	18.8	0.8
March, 2010	34.6	21.4	29.1	10.9	2.1

3.4 Mandate crops :

1. Coriander (*Coriandrum sativum* L.)
2. Cumin (*Cuminum cyminum* L.)
3. Fennel (*Foeniculum vulgare* Mill.)
4. Fenugreek (*Trigonella foenumgraecum* , *Trigonella corniculata* L.)
5. Ajowan (*Trachyspermum ammi* Sprague)
6. Dill (*Anethum graveolens* L., *Anethum sowa* Kurz.)
7. Nigella (*Nigella sativa* L.)
8. Aniseed (*Pimpenella anisum* L.)
9. Celery (*Apium graveolens* L.)
10. Caraway (*Carum carvi* L.)

3.5 Objectives:

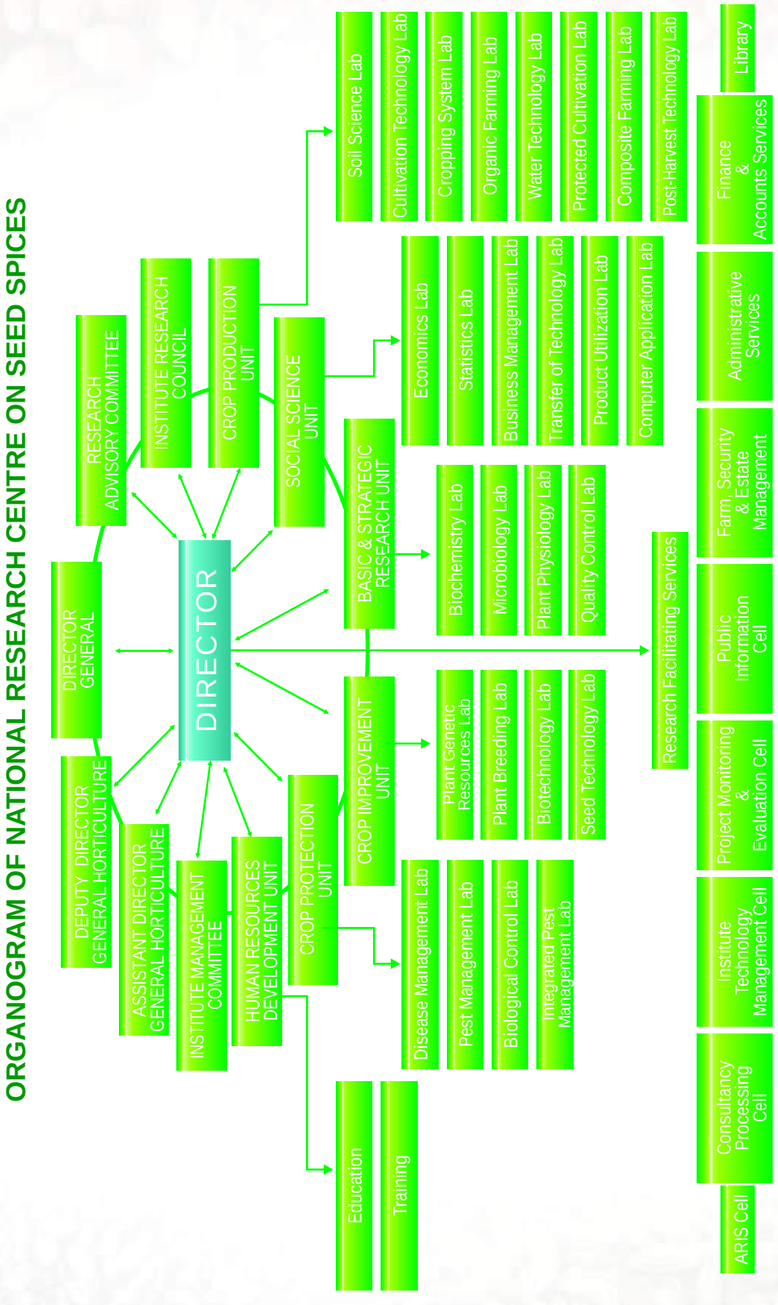
1. Collection, evaluation, characterization and conservation of germplasm.
2. Breeding variety with high yield potential, quality and resistance to biotic and abiotic stresses.
3. Developing efficient agro-techniques for achieving the high production and productivity.
4. Evolving better and efficient management system for control of pests and diseases.
5. Study of nutritional and water management aspects.
6. Development of package on organic farming of the seed spices for export, based on environment friendly production and potential technology.
7. Research on seed technology for production of quality seeds of improved varieties.
8. Study of economics of production and marketing.
9. Development of pre and post harvest technology for better processing, storage and utilization.
10. Development of export oriented technology for export of raw and value-added products.
11. Transfer of technology for farmers and extension agencies.

3.6 FINANCIAL OUTLAY

HEAD	PLAN		NON- PLAN	
	RE 2010-11	Expenditure	RE 2010-11	Expenditure
Establishment	191.38	170.45	0.00	0.00
TA	1.00	1.00	5.00	4.99
Other charges including equipment	88.32	87.32	109.00	60.46
Works	0.00	0.00	95.00	143.56
HRD	0.00	0.00	6.00	5.99
Total	**280.70**	**258.86**	**215.00**	**215.00**

3.7 STAFF POSITION on 31-3-2011

Grade	Sanctioned	Filled	Vacant
Scientific	21	18	3
Technical	8	7	1
Administration	5	4	1
Supporting	2	2	-
Total	**36**	**31**	**5**



4. RESEARCH ACHIVEMENTS

The research activities at NRCSS, Ajmer is presently being carried out under five scientific sections: Crop Improvement, Crop Production, Crop Protection, Basic Sciences and Social Science. The other supporting units of the centre are: Library, Farm, Establishment, Administrative, Audit & Accounts.

4.1 CROP IMPROVEMENT

CI-1. Management of plant genetic resources of seed spices crops

Collection of germplasm

During the year 2009-10, two explorations were conducted successfully. These explorations were done in collaboration with the apex body National Bureau of Plant Genetic Resources (NBPGR), New Delhi. Representatives of corresponding regional centres of NBPGR actively participated along with NRCSS scientists for performing these explorations. Total 58 indigenous collections were made of various seed spices. Moreover, 54 exotic fenugreek accessions belonging to nine countries were also procured from International Centre for Research in Dryland Areas (ICARDA), Aleppo, Syria. The salient achievement of germplasm collection is as under:

- From Chattisgarh region Dr. R.S. Mehta collected accessions of coriander (21), fennel (6), fenugreek (4), Nigella (2)
- From Punjab region Dr. Sharda Choudhary and Dr. Vishal collected 25 accessions of cellary
- 54 exotic fenugreek lines (native of nine countries) were procured from ICARDA. The detail country wise list of accessions is mentioned below :

o Oman	-	14 accessions
o Egypt	-	7 accessions
o Syria	-	4 accessions
o Algeria	-	4 accessions
o Tunisia	-	4 accessions
o Jordan	-	2 accessions
o Morocco	-	5 accessions
o Nepal	-	11 accessions
o Pakistan	-	3 accessions

Evaluation and maintenance of germplasm

All the germplasm stock is maintained by each curator of each spice crop by growing them at NRCSS, Ajmer farm. During this season, early flowering coriander, cumin, dill, ajwain, nigella, anise, celery and caraway germplasm lines were maintained.

During the year 2009-10, multilocation evaluation of cumin, coriander, fennel, fenugreek, ajwain and dill was also initiated. The second year evaluation of the same set of each crop will also be done in the year 2010-11. Curators of each crop was declared as leader of that crop for all multilocation evaluations. The experimental details are presented in table 4.1 to 4.3

Characterization and documentation

After the meeting of All India spice workers descriptors was finalized and observation on all descriptors will be taken by curators and will be published in catalogues. For characterization and documentation of germplasm available with different centres evaluation will be carried out in two year multilocation testing.

Table 4.1: Centres for coriander germplasm evaluation

Group	Testing centre and lines to be contributed by that centre to other group members			Additional lines to be contributed to each centre of the group	Group Leader
I	Guntur (60)	Coimbatore (30)	Dharwad (0)	---	Guntur
II	Raigarh (7)	Dholi (30)	Kumarganj (30)	Jobner (23)	Dholi
III	Solan (8)	Pantnagar (0)	Ajmer (30)	Jobner (52)	Ajmer
IV	Jobner (30)	Hisar (30)	Jagudan (30)	---	Jobner

Table 4.2; Centres for fennel germplasm evaluation

Group	Testing centre and lines to be contributed by that centre to other group members			Additional lines to be contributed to each centre of the group	Group Leader
I	Ajmer (20)	Jobner (40)	Jagudan (30)	---	Jagudan
II	Hisar (30)	Dholi (25)	Kumarganj (30)	Jagudan (5)	Kumargang
III	Pantnagar (0)	Raigarh (0)	Guntur (0)	Jobner (30), Jagudan (30), Hisar (30)	Pantnagar

Table 4.3: Centres for fenugreek germplasm evaluation

Group	Testing centre and lines to be contributed by that centre to other group members			Additional lines to be contributed to each centre of the group	Group Leader
I	Guntur (0)	Coimbatore (0)	Dharwad (0)	Jagudan (30), Jobner (10)	Coimbatore
II	Jabalpur (0)	Dholi (25)	Kumarganj (30)	Jobner (20), Hisar (15)	Jabalpur
III	Solan (0)	Pantnagar (0)	NBPGR (30)	Ajmer (30)	NBPGR
IV	Jobner (30)	Hisar (30)	Jagudan (30)	---	Hisar

Conservation of seed spices plant biodiversity

CI-2. Breeding for high yield, quality and resistance to biotic and abiotic stress in fenugreek

Collection of fenugreek germplasm

This year total 58 germplasm lines were added to fenugreek gene pool, out of which 4 were collected from chattisgarh region and 54 exotic accessions were procured from ICARDA, Aleppo, Syria.

Table 4.4: Total germplasm assemblage at NRCSS

Crop	Indigenous	Exotic	Lost	Present available	NAGS holding
Cumin	70	7	-	77	217
Coriander	141	3	27	117	404
Fenugreek	80	59	6	133	394
Fennel	103	3	75	31	282
Ajowain	94	1	9	86	95
Dill	100	5	3	102	105
Nigella	19	3	-	22	22
Celery	36	-	-	36	36
Anise	13	-	-	13	13
Caraway	8	2	8	2	10
Total	**664**	**83**	**128**	**619**	**1578**

Characterization of fenugreek germplasm for morphological and yield attributes

A total of 66 fenugreek lines collected in the past three years were evaluated for 33 morphological attributes in augmented design with three check varieties. Variability recorded in screened germplasm is described in table 4.5 and promising accessions identified for each character is presented in table 4.6.

Table 4.5: Extent of variability recorded in fenugreek germplasm

Character	Min.	Max.	Average	CV (%)
No. of primary branches	4.4	8.8	5.95	13.81
No. of secondary branches	0.6	14.8	3.79	76.55
Plant Height (cm)	24	61.8	46.28	20.27
Pod length (cm)	6.53	12.32	10.0	11.50
No. of Pods/plant	3	57.2	25.7	43.57
No. of Seeds/pod	10.05	17.00	14.08	12.15
Test Weight (g)	3.725	19.296	12.45	24.76
Yield/plant (g)	0.23	11.9	5.66	45.73

Table 4.6: Promising fenugreek accessions identified as per characters studied

Character	Superior accessions
No. of primary branches (>7)	AM-292, AM-299, AM-298, AM-311, AM-327, & AM-319
No. of secondary branches (>8)	AM-299, AM-327, AMN-330, AM-316, AM-321 & AM-305
Plant Height (cm) (>57 cm)	AM-298, AM-288, AM-300, AM-287, AM-329, AM-295, AM-283 & AM-282
Pod length (cm) (>11.5 cm)	AM-293, AM-324, AM-329, AM-278, AM-326 & AM-328
No of Pods/plant (>40)	AM-300, AM-292, AM-323, AM-324 & AM-282
No of Seeds/pod (>16)	AM-301, AM-300, AM-303, AM-287, AM-310, AM-311, AM-304 & AM-308
Test Weight (g) (>17 g)	AM-329, AM-328, AM-288, AM-287 & AM-290
Yield/plant (g) (>9 g)	AM-324, AM-288, AM-329, AM-317, AM-326 & AM-278

Breeding for resistance to powdery mildew in fenugreek

Observation on powdery mildew incidence was recorded both on germplasm stock and genotypes evaluated under station trials. None of the accessions and genotypes showed absolute resistance against powdery mildew.

Creation of variability through mutation breeding

As mentioned in earlier reports, mutation breeding programme was started with two genotype of fenugreek treated with different levels of gamma rays. This year total 152 M_3 lines were sown in single row plot of two meter, variants for plant type, plant height, leaf shape & size and growth behaviour were selected. Lines showing desirable extent of variability were harvested separately. Simultaneously, 240 lines of M_2 generation of UM-344 developed through five mutagen doses were raised in the field. From this population variants were selected and advanced. Variability for powdery mildew reaction was recorded on whole of the mutant set generated, none of the mutant showed complete resistance. Disease intensity (DI) varies from 27.5 to 77.5 per cent, whereas parent showed 50 per cent DI. Mutant line A3-45-7 showed least infection i.e. 27.5 % DI followed by B1-18-2 and B3-32-1 (30%).

Plate.4.1 : Mutant line showing (a) Late maturity and (b) Less powdery mildew incidence

CI- 3. Breeding for high yield and quality in coriander

This project started in the year 2007-08 with the objective to develop genotypes having high yield and good quality i.e. high essential oil content. This year total 123 lines including 21 indigenious lines of chattisgarh region were evaluated along with six check varieties. Variability was recorded for yield contributing characters. Potential lines were identified and advanced for next season Station Trial. Advance lines (12 genotypes) were evaluated in rod row plots with two check varieties namely RCr-435 and Ajmer Coriander-1. As per yield 7 genotypes out yielded the best check RCr-435 (Fig. 4.1). Best performing selection was half sib selection from UD -401 followed by Dhana 397. As per least test weight (market desirability), genotype MSKM 1059 showed higher yield than best check.

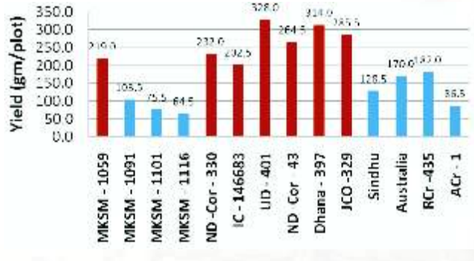


Fig 4.1: Performance of coriander populations

Three gene pools (Composites) were prepared. (1) Early maturing and high yielding (2) Small seed size pool (3) A pool with 4 basal leaf, medium height, higher no. of seed per umbel and higher yield. These three gene pools were planted at NBPGR Regional Station, Wellington in Kharif, 2009 (I^{st} Generation). The material received from Wellington was planted in *rabi, 2009-10* at NRCSS, Ajmer (II^{nd} Generation).

CI-4. Breeding for high yield, quality and resistance to biotic and abiotic stress in fennel

This project started in the year 2009-10 with the objective to develop fennel genotypes having higher yield along with resistant to abiotic stress specially Ramularia blight and abiotic stress specially productive growth under limited water conditions. During the year 2009-10, 28 germplasm lines were sown and evaluated for dwarfness and yield with 2 checks viz AF-1& RF-101. All major observations were recorded, large amount of variability was found in the set of lines analysed. Total variability recorded is presented in table 4.7. The range of plant height was 79-154.8 and range of yield per plot was 420-1000. The highest mean of yield per plot was 358.16 g and of plant height was 112.97 cm. The maximum CV was found for yield per plot ie., 63.05% and lowest CV was recorded for umbellate per umbel ie., 17.25%. Best performance for seed yield and plant height among the fennel genotypes evaluated was found for AF-87 (Dwarf type; Seed Yield: 552 g, Plant Height:101.8 cm) followed by AF-01-30-1(Seed Yield: 1000g, Plant Height: 111 cm), and AF-05-2 (Seed yield; 565 g, Plant Height: 134.8 cm).

Table 4.7: Variability recorded in fennel

Character	Max.	Min.	Mean	CV (%)
Inter Nodes (Nos.)	7	3	4.92	17.26
Primary angle (Degree)	40.2	11	23.75	33.89
Secondary angle (Degree)	46.6	14	27.99	31.02
Plant height (cm)	154.8	79	112.97	17.25
No of Branches	18.4	9.5	13.84	17.08
No of Umbel /plant	35.2	11.4	18.11	28.86
No of Umbellate / umbel	29.6	14.2	22.38	15.61
No of Seed /umbel	67.2	18.4	25.37	41.12
Test weight (g)	8.16	3.32	5.85	20.41

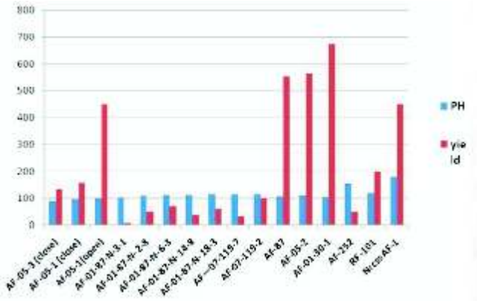


Fig 4.2: Performance of fennel genotypes for height and yield

CI-5. Breeding for high yield, quality and resistance to biotic and abiotic stress in cumin

This project started in the year 2009-10 with the objective to develop cumin genotypes having high seed yield along with resistant to abiotic stress specially blight, wilt and abiotic stress specially for productive growth under limited water conditions. Under which, during the year 2010-11, 62 germplasm lines were sown and evaluated for yield & contributing characters with two checks GC-4 & RZ-19. Total variability recorded is presented in table 4.8. The range of variability for plant height was 9-53 cm and the mean performance was 31.24 cm with CV percent

Table 4.8: Variability recorded in cumin

Character	Max.	Min.	Mean	CV (%)
Plant height (cm)	53	9	31.24	13.06
No. of branches	4.87	0.78	4.29	23.53
No. Umbel per plant	50	2.4	12.42	59.53
No of Umbellate/ umbel	39	2.6	4.34	16.72
No. of Seed per umbel	12	2.8	5.73	13.89
Test weight (g)	9.6	0.42	4.38	21.74
Seed Yield/ Plot (g)	48.84	0.14	12.1	40.35

13.06. Among the traits studied, the maximum CV was found for umbel per plant (59.53%) followed by yield per plant (14.35%). Which shows that ample amount of variability exist in these lines for respective traits. Accessions found superior for seed yield were JC-2000-20 (48.84 g), JC-99-37 (26.2 g), JC-2000-23 (21.88 g) and JC-96-36 (20.75 g).

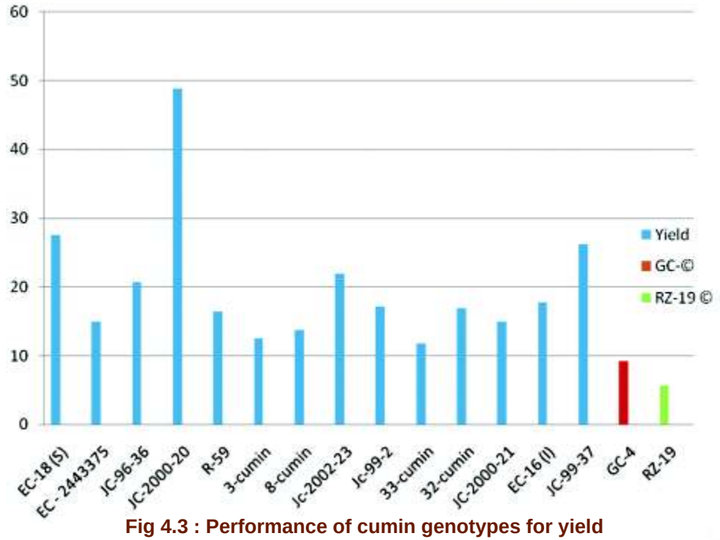


Fig 4.3 : Performance of cumin genotypes for yield

CI-6. Breeding for high yield, quality and resistance to biotic and abiotic stress in caraway

This project started in the year 2009-10 with the objective to develop celery genotypes having higher yield along with resistant to abiotic & biotic stress. During the year 2010-11, four germplasm lines were sown and evaluated for yield with one local check. All observations were recorded and are presented in Table 4.9. The variability for seed yield was found in the range of 3.84-5.37 gm. The mean performance of seed yield was found to be 4.60 g with CV 23.49%.

Table 4.9: Variability recorded in caraway

Character	Max.	Min.	Mean	CV (%)
Plant height (cm)	56.4	38	47.20	27.57
No. of branches	14.8	14.6	14.70	0.96
Primary Angle (Degree)	22	20	21.00	6.73
Secondary Angle (Degree)	32.6	26	29.30	15.93
No. of Umbel /plant	14	12	13.00	10.88
No. of Umbellate /umbel	10.2	10	10.10	1.40
No. of Seed /umbel	7.4	6.4	6.90	10.25
Test weight (g)	0.5	0.4	0.45	15.71
Seed Yield/Plot (g)	5.37	3.84	4.60	23.49

CI-7. Breeding for high yield, quality and resistance to biotic and abiotic stress in celery

This project started in the year 2009-10 with the objective to develop celery genotypes having higher yield along with resistant to abiotic & biotic stress. 13 germplasm lines were sown and evaluated for yield with 2 checks (Local & Acel-1). All major observations were recorded, the variability for yield was found in the range of 25.5-70.5 and the mean was 42.19 with CV 30.63 %. The maximum CV was found for test weight (37.21%) followed by umbel per plant (31.67%). It shows that variability exists in these lines. Better performing celery accessions for seed yield were Cel-08 (70.5 g), Acel-2 (40.5 g) and Acel-6 (39.5 g).

Table 4.10: Variability recorded in celery during 2009-10

Character	Max.	Min.	Mean	CV (%)
Plant height (cm)	29	16.4	22.96	19.67
No. of branches	20	10	15.69	15.55
No. of Umbel /plant	33.2	12	23.23	31.67
No. of Umbellate /umbel	13.8	7.4	10.97	16.77
No. of Seed /umbel	245.6	77.6	150.31	26.04
Test weight (g)	5.57	1.23	3.37	37.21
Seed yield /plot (g)	70.5	25.5	42.19	30.63

CI- 8. Breeding for high yield and quality in dill

Evaluation and maintenance of dill germplasm

During the year 2009-10, 96 lines of dill available at NRCSS, Ajmer were evaluated in Augmented design with two check varieties namely AD-1 and AD-2. Observations on yield attributes were recorded.

Development of improved varieties

On the basis of the previous year's observations one station trial was conducted with 10 test entries and two check varieties namely AD-1 and AD-2. Five entries namely AD-01-4, AD-S-11, AD-S-01-3, AD-S-01-4 and AD-S-01-28 out yielded the best check

Fig. 4.4: Performance of dill genotypes in station trial

CI-9: Breeding for high yield and improved quality in ajwain for *rabi* and *kharif* season

During the year 2009-19, 50 germplasm lines of Ajwain were grown in *kharif* season and same germplasm lines were raised in *Rabi* season also. Recommended package of practices were followed to raise the germplasm lines. Necessary observations on growth parameters, yield attributes and yield were recorded. Eight genotype were identified for earliness, which will be re-evaluated in the coming season for stability of the trait. Variability recorded for growth parameters are presented in Table 4.11 and 12.

Table 4.11: Variability recorded in ajwain genotypes tested in *kharif* 2009

Character	Max.	Min.	Mean	CV (%)
Days to Germination	9	5	7.5	25.7
Plant height (cm)	100	42	76.7	15.2
No. of Primary branches/ plant	37	5	13.9	27.2
No. of Secondary branches/ plant	277.5	24	108.2	49.1
Days to 50% Flowering	85	67	80.7	11.2
Main umbel Diameter (cm)	4.9	2.6	3.7	12.7
No. of Umbels /plant	408	40	176.4	41.6
No. of Umbellates / umbel	13.5	7	9.9	13
No. of Seeds /umbellate	28	9	14.3	20.2
Test weight (g)	9.5	0.3	1.2	86.2

Table 4.12: Variability recorded for ajwain genotypes evaluated during *rabi* 2009-10

Character	Max.	Min.	Mean	CV (%)
Days to Germination	9	7	8.13	11.67
Plant height (cm)	90	46	65.92	18.02
No. of Primary branches/ plant	20	6.67	13.16	21.71
No. of Secondary branches/ plant	65	11.3	37.71	38.75
Days to 50% Flowering	143	55	89.92	20.05
Main umbel Diameter (cm)	6.27	3.87	4.84	21.04
No. of Umbels /plant	122.3	18	59.11	35.98
No. of Umbellates / umbel	19.67	8.67	14.68	15.29
No. of Seeds /umbellate	23.33	14	17.24	21.51
Test weight (g)	2.19	1	1.38	37.89
Seed yield / plant (g)	98	2	35.05	79.5

CI-10: Breeding for high yield and improved quality in Nigella

One station trial on nigella comprising 10 advance line along with two check namely Ajmer Nigella -1 and Azad Kalongi were undertaken during the year 2009-10. Only days to flowering were observed but other yield and yield

attributes were not recorded as trial failed. The same trial will be repeated in the coming season.

CI-11: Genetic characterization and documentation of released varieties of cumin, coriander, fenugreek and fennel

Morphological observation of yield and yield contributing characters were taken for all the released varieties available at NRCSS. The genomic DNA of all the 58 released varieties of seed spices (6 of cumin, 22 of coriander,13 of fennel and 17 of fenugreek) have been isolated and quantified using HiPura Plant genomic Kit of Himedia. The genetic diversity analysis of 17 released varieties of Fenugreek has been done using RAPD technique. ITS sequence diversity analysis was also done in fenugreek, representative sequences of each subgroup and all out groups of fenugreek have been submitted to NCBI database and assigned Gen Accession numbers HM 176640-176649. Again for cumin also, ITS regions were analysed and the representative sequences of each subgroup and all out groups have been submitted to NCBI database and assigned Gen Accession numbers HM176650- HM176655. RAPD profile of 17 fenugreek varieties is presented in plate 4.2 and dendrogram in plate 4.3.

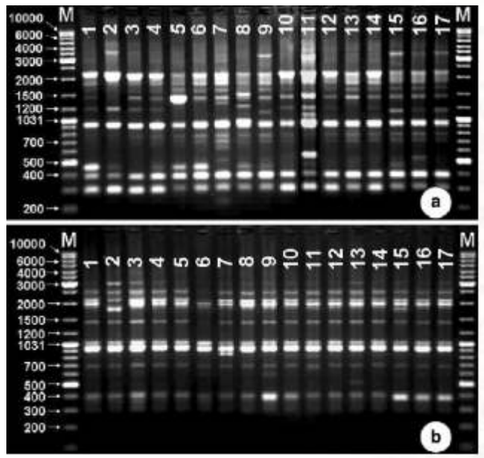


Plate 4.2: RAPD profiles of 17 varieties of fenugreek generated using two primers (a.OPP-02 and b.OPP-09)

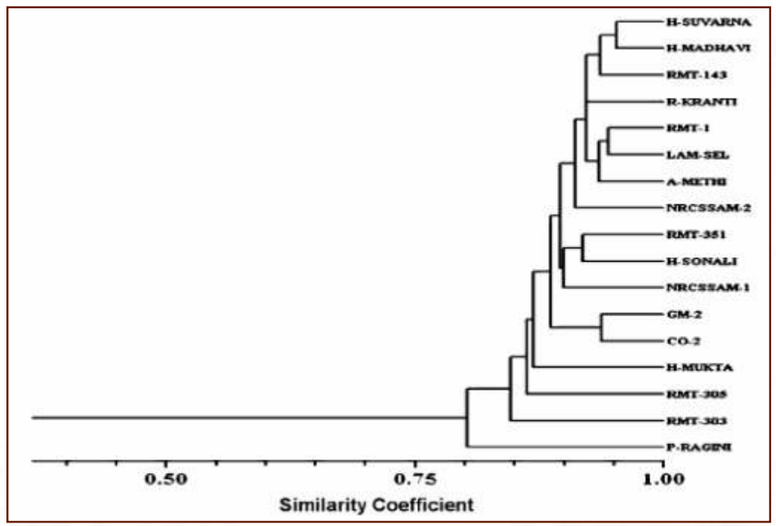


Plate 4.3: Dendrogarm of 17 fenugreek varieties

4.2 Crop Production

CPd-2: Nutrient Influx Efficiency in *Coriandrum sativum*, *Foeniculum vulgare* and *Trigonella foenum-graecum* cultivars

Nutrient uptake study in coriander cultivars under semi arid conditions:

Uptake distribution of nitrogen indicates that N uptake through coriander straw was highest in cultivar RCr-446 (Fig.4.5) and was least in cultivars Co-2, which was approximately double in RCr-446 than Co-2. However rest of the cultivar showed medium level of N uptake through straw. In case of N uptake through coriander seed was maximum in Co-2 followed by Rajendra Swathi and was least in Ajmer coriander-1. Phosphorus accumulation was highest in RCr-41 seeds and was least in Co-2 accounting half of RCr-41 (Fig.4.6). However, P accumulation in straw was highest in RCr-446 and was least GCr-2. Potassium accumulation in straw of coriander cultivars RCr-41 showed maximum accumulation and was least in Co-2 which was approximately 2.5 times more than the lowest one. However, potassium accumulation was more in seeds of Hisar Suganda and was least in Rajendra Swathi. The total N removal was highest in RCr-446 followed by Rajendra Swathi and was least in Co-2 (Fig.4.8). The total P removal was also maximum in RCr-446, whereas least in GCr-2, this account approximate 1.5 times more than the Co-2. The total of removal of K was highest in RCr-41 followed by Hisar Sugandha and was least in Rajendra Swathi. The difference among least and highest removal of K was 1.5 times.

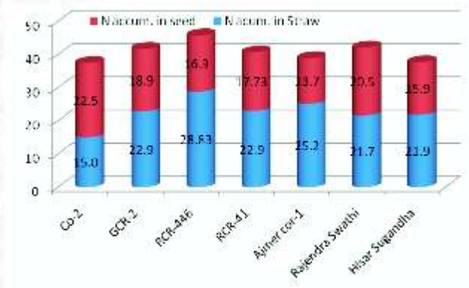


Fig 4.5: Nitrogen uptake (kg/ha) pattern in coriander cultivars

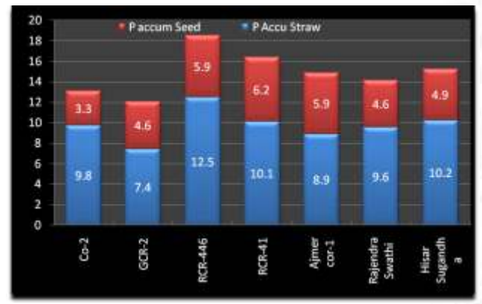


Fig 4.6: Phosphorus uptake (kg/ha) pattern in coriander cultivars

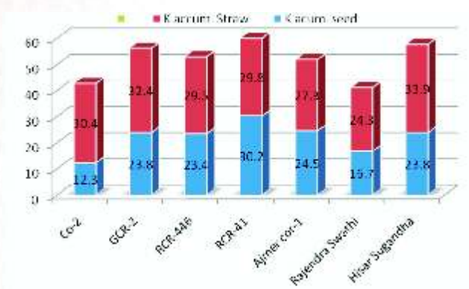


Fig 4.7: Potassium uptake (kg/ha) pattern in coriander cultivars

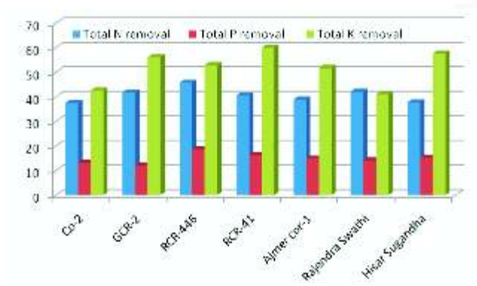


Fig 4.8: NPK removal (kg/ha) by coriander cultivars

Nutrient uptake study in fennel cultivars under semi arid conditions:

The NPK removal through fennel cultivars and in their parts were assessed and it was found that N accumulation was highest in fennel seeds of GF-1 was least in AF-1-87 cultivar (Fig.4.9). However, N accumulation in straw was highest in PF 35 followed by RF-101 and was least in cultivar AF-S-01. Phosphorous in seeds was significantly higher in GF-2 and rest of the cultivars remained at par (Fig.4.10). In case of P accumulation in straw was highest and was least in GF-2. Potassium accumulation in fennel seed was highest in GF-2 and was least in PF-35 (Fig.4.11). In straw, highest uptake was in RF-101 and was least in AF-187, which was approximately half of the highest value. Total N removal was highest in GF-2 and was least in GF-1 and AF-S-01 (Fig.4.12). The total P removal was highest in RF-101 and was least in AF-S-01. The total potassium removal was least in AF-187 and was highest in RF-101, this difference was 1.5 times higher than the existing least and highest value.

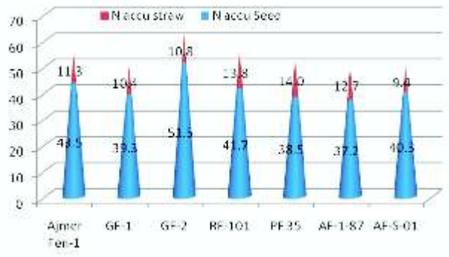


Fig 4.9: Nitrogen uptake (kg/ha) pattern in fennel cultivars

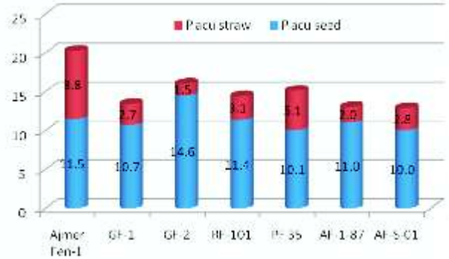


Fig 4.10: Phosphorus uptake (kg/ha) pattern in fennel cultivars

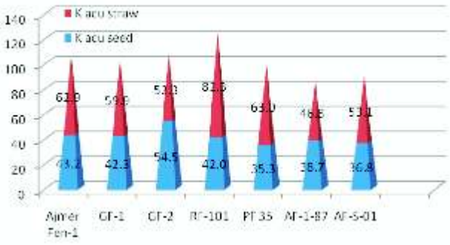


Fig 4.11: Potassium uptake (kg/ha) pattern in fennel cultivars

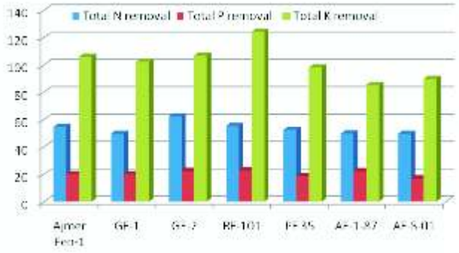


Fig 4.12: NPK removal (kg/ha) by fennel cultivars

Nutrient uptake study in fenugreek cultivars under semi arid conditions:

NPK uptake distributions in fenugreek cultivars were assessed and NRCSS AM-1 found highest N accumulator in seed and was least in RMT-305 with the wide difference of approximately two times (Fig.4.13). In straw highest accumulation was in RMT-1 followed by Rajendra kranti and was least in Ajmer fenugreek 1. Phosphorous accumulation in seed of Ajmer fenugreek-1 was highest and was least in RMT-305 and that is half of highest uptake value from Ajmer fenugreek-1 (Fig. 4.14). P accumulation in straw of RMT-1 was highest and least in RMT-305 within the evaluated fenugreek cultivars. Potassium accumulation in fenugreek seed was highest in Ajmer fenugreek-1 and least in RMT-305 which accounts half of the Ajmer fenugreek-1, whereas K accumulation in straw was least in Ajmer fenugreek-2 and highest in NDM-1, which is 1.7 times more than the lowest accumulated cultivars (Fig.4.15). The total removal of Nitrogen was highest in RMT-1 and was least in RMT-305. The difference among the least and highest N removal by the fenugreek cultivars was 1.5 times (Fig.4.16). However, total removal of P was 1.5 times more in Ajmer fenugreek-2 than the RMT-305. The total removal of potassium by the fenugreek cultivars showed that RMT-1 accumulated maximum K and least by RMT-305.

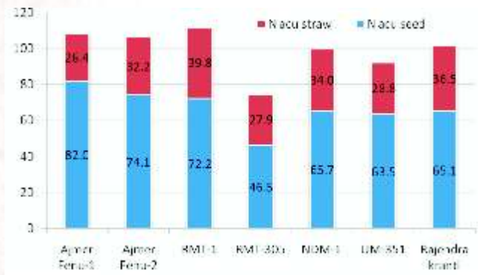


Fig 4.13: Nitrogen uptake (kg/ha) pattern in fenugreek cultivars

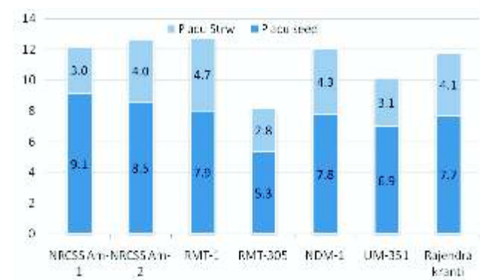


Fig 4.14: Phosphorus uptake (kg/ha) pattern in fenugreek cultivars

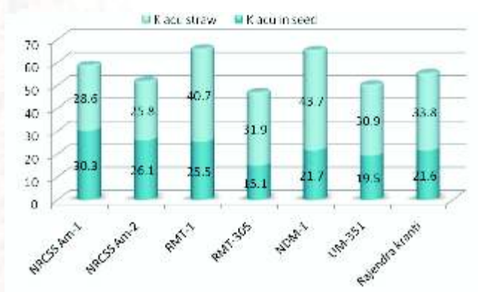


Fig 4.15: Potassium uptake (kg/ha) pattern in fenugreek cultivars

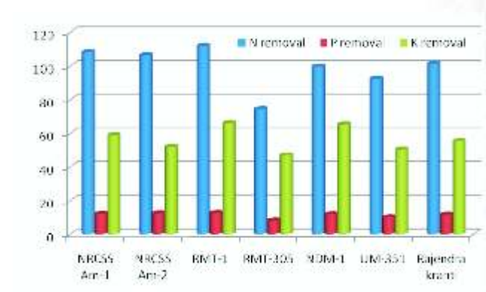


Fig 4.16: NPK removal (kg/ha) by fenugreek cultivars

CPd-3: Optimization of water requirement in major seed spices

Field experiments were carried out on coriander with IW:CPE ratio comprising 0.4, 0.6, 0.8, 1.0 and 1.2. Plant height of coriander increased up to IW:CPE ratio 0.6 and remained at par with IW:CPE ratio 0.8 and reduced thereafter (Fig 4.17). The number of branches were also more with IW:CPE ratio 0.6. However there was no significant variation found among the treatments. Yield of coriander increased up to IW:CPE ratio was 0.6 and remained at par with IW:CPE ratio 0.8 and reduced thereafter (Fig 4.18). The yield of coriander with corresponding IW:CPE ratio 0.4, 0.6, 0.8, 1.0 and 1.2 was 4.7, 8.3, 7.8, 6.8 and 6.5, respectively. Soil organic carbon decreased with increase in IW:CPE ratio (Fig 4.19). Soil organic carbon varied from 0.29-0.25% with various IW:CPE ratios.

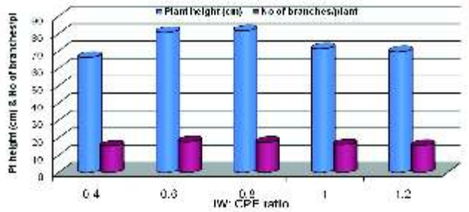


Fig 4.17: Growth parameters of coriander with various IW:CPE ratio

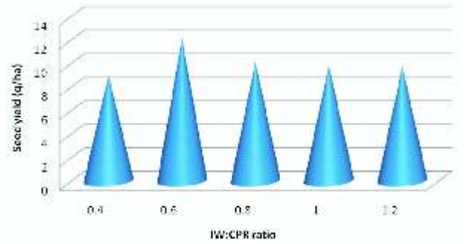


Fig 4.18: Yield of coriander with various IW:CPE ratio

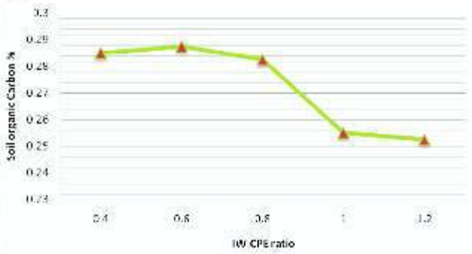


Fig 4.19: Soil organic carbon after coriander with various IW:CPE ratio

CPd-4: Performance of seed spices in problematic soil and water resources

Performance of coriander with soil pH

Plant height was at par up to pH 7.0 and reduced thereafter. Plant height reduced about 42% at pH 8.5 as compared to neutral pH (Fig. 4.20). No of primary branches were more with neutral pH than the lower and higher pH, whereas secondary branches were only lower at pH 8.0 and 8.5 and remained at par at rest of the pH (Fig.4.21). No of umbel/plant, number of umbelets/plant and number of seed per umbel were at par with neutral to acid side and reduced beyond the neutral pH (Fig. 4.22). Number of umbel/plant was half at pH 8.5 than the neutral and acid pH. Straw accumulation was increased with increase in pH up to neutral level and reduced thereafter. Straw accumulation was 8-10 times lower at pH 8.5 than the neutral or acid side pH. Whereas, seed produced by the Ajmer coriander-1 was 5-6 time lower with the alkaline pH then the neutral to mild acid pH (Fig. 4.23). Harvest index was at par with pH acid to neutral pH and was lowest at pH 7.5 (Fig.4.24).

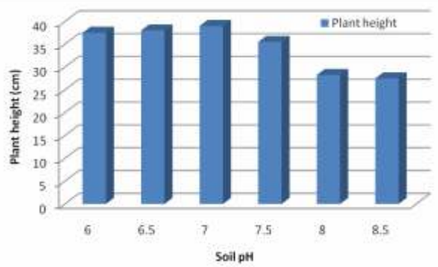


Fig 4.20: Plant height of coriander with mild acid to alkaline soil pH

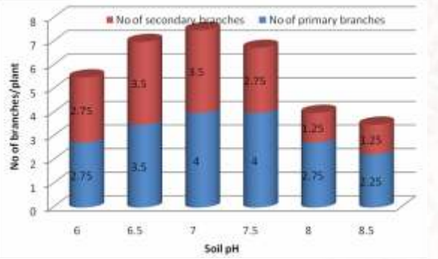


Fig 4.21: No of primary and secondary branches in coriander with mild acid to alkaline soil pH

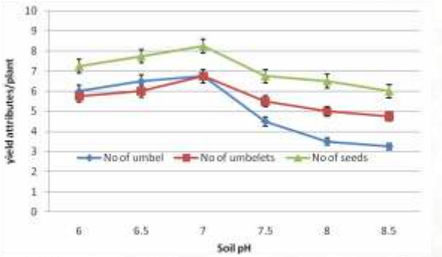


Fig 4.22: Yield attributes of coriander with mild acid to alkaline soil pH

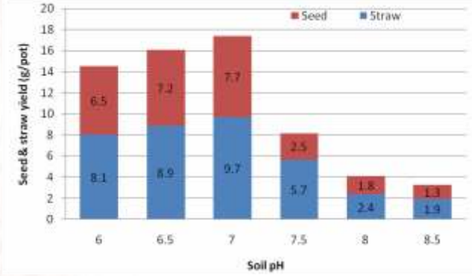


Fig 4.23: Yield of coriander with mild acid to alkaline soil pH

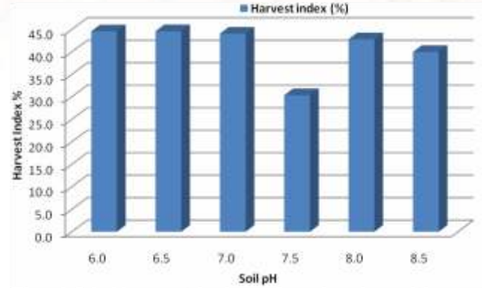


Fig 4.24: Harvest index of coriander with mild acid to alkaline soil pH

CPd-5: Standardization of protected cultivation techniques for seed crops

Erratic weather conditions cause the sizable loss in seed spices particularly in cumin and coriander caused by frost and infestation og insect pests and diseases during conventional and offseason.therefore, investigations were carried out to standardise the protected cultivation techniques for seed spices under different irrigation systems. There were five treatments of protection namely, Plastic walk in tunnel, Insect proof net tunnel, Shade net tunnel, Plastic low tunnel and Open conditions (Control) and three irrigation treatments (Low pressure drip irrigation, Pressurised drip irrigation and Flood irrigation).

Effect of protection structures and irrigation methods on cumin

Growth attributes like plant height at 45 and 90 DAS as well as at harvest was significantly influenced with different protected cultivation practices (table 4.12). The plant height at 45 DAS (22.67) and plant height at harvest (30.17) were recorded highest with insect proof net tunnel. The lowest values of these growth attributes were exhibited in plastic walk in tunnel. The maximum number of umbels per plant (19.33), umbellate per umbel (5.67), seed per umbellate (7.33), test weight (4.56) and seed yield (930.74kg/ha) were obtained in insect proof net tunnel followed by plastic walk in tunnel in cumin.

Irrigation methods also significantly influence plant height at 60DAS as well as at harvest. Yield attributes and yield of cumin were significantly influenced with irrigation method. Application of irrigation by low pressure drip exhibited significantly highest umbels per plant (17.73), umbellate per umbel (5.40), seed per umbellate (6.80), test weight of seed (4.91g) and seed yield (663.28 kg/ha).

Plant height at 60 DAS and at harvest, umbel/ plant, umbellates/ umbel, seed/ umbellate, test weight and seed yield were significantly influenced with interaction effect between protected cultivation practiced and irrigation methods. The highest value for all the above characters were 24.33, 32, 22, 5, 8, 5.43, and 975.56, respectively and was recorded with Insect proof net tunnel protected cultivation irrigated with low pressure drip (Table 4.13).

Table 4.12: Effect of irrigation methods and various protected cultivation practices on growth attributes of cumin

Treatments	Plant height at 45 DAS (cm)	Plant height at harvest(cm)	Branches /plant
P_1.-Plastic walk in tunnel	18.30	26.83	5.44
P_2-.Insect proof net tunnel	22.67	30.17	5.34
P_3-.Shade net tunnel	20.42	27.33	6.06
P_4.Plastic low tunnel	19.39	25.00	5.70
P_5.Open conditions	19.21	31.22	6.08
SEm±	**0.68**	**0.95**	**0.19**
CD (P=0.05)	**2.21**	**3.11**	**0.62**
I_1. low pressurized drip irrigation	19.25	27.60	5.59
I_2 pressurized drip irrigation	20.39	29.00	5.76
I_3 flood system	20.35	27.73	5.83
SEm±	**0.44**	**0.59**	**0.12**
CD (P=0.05)	**1.29**	**1.75**	**0.36**
Interaction PXI	S	S	NS

Table 4.13: Effect of irrigation methods and various protected cultivation practices on yield attributes and yield of cumin

Treatments	Umbels/ plant	Umbellate/ umbel	Seed/umbellate	1000-seed wt(g)	Seed Yield kg /ha
(A) Main plot –Protected Environment (P)					
P_1.-Plastic walk in tunnel	18.33	5.00	7.00	4.37	580.09
P_2-.Insect proof net tunnel	19.33	5.67	7.33	4.56	930.74
P_3-.Shade net tunnel	15.44	5.00	6.00	3.82	425.37
P_4.Plastic low tunnel	7.00	3.67	4.33	3.20	373.89
P_5.Open conditions	17.33	5.33	6.33	4.34	790.00
SEm±	0.54	0.13	0.13	0.14	20.16
CD (P=0.05)	1.76	0.42	0.42	0.44	65.72
(B) Irrigation methods(I)					
I_1. low pressurized drip irrigation	17.73	5.40	6.80	4.91	663.28
I_2 pressurized drip irrigation	15.40	5.00	6.20	3.89	640.83
I_3 flood system	13.33	4.40	5.60	3.38	555.94
SEm±	0.32	0.09	0.12	0.08	11.23
CD (P=0.05)	0.95	0.28	0.36	0.24	74.09
Interaction PXI	S	S	S	S	S

Effect of protection structures and irrigation methods on coriander at Ajmer

The plant height at 60 days (15.13), plant height at harvest (96.78), no. of basal leaves (8.10) and branches per plant (8.18) were recorded highest with plastic walk in tunnel (Table 4.14). and lowest in plastic low tunnel. The maximum umbels per plant (113.33), umbellate per umbel (8.22), seed per umbellate (7.67), test weight (7.77) and seed yield (1577kg/ ha) were obtained in insect proof net followed by shade net tunnel. Application of irrigation by low pressure drip exhibited significantly highest umbels per plant (96.60) and seed yield (217.87kg/ha).

Umbels per plant and seed yield were significantly influenced with interaction effect between protected cultivation practiced and irrigation methods. The highest umbels per plant (119.67) and seed yield (1689 kg/ha) was recorded with Plastic walk in tunnel protected cultivation irrigated with low pressure drip (Table 4.15).

Offseason coriander

Offseason coriander was grown at NRCSS Ajmer with 6 protection treatment namely control, white net, green net, black net (75%), Black net (60%) and Black net (50%). The coriander was grown during July-September, 2009. Green net exhibited best results with respect to seed germination, growth, yield and yield attributes of coriander.

Table 4.14: Effect of irrigation methods and various protected cultivation practices on growth attributes of coriander

Treatments	Plant height at 60 DAS (cm)	Plant height at harvest (cm)	No. of basal leaves	Length of basal leaves	Branches /plant
(A) Main plot –Protected Environment (P)					
P_1.-Plastic walk in tunnel	15.13	96.78	8.10	22.23	8.18
P_2-.Insect proof net tunnel	14.96	84.00	7.13	19.73	7.98
P_3-.Shade net tunnel	14.43	73.44	6.10	17.23	7.50
P_4.Plastic low tunnel	12.20	46.89	5.67	15.83	6.72
P_5.Open conditions	14.16	84.22	7.00	17.73	7.36
SEm±	0.47	2.74	0.23	0.62	0.25
CD (P=0.05)	1.53	8.95	0.74	2.01	0.82
(B) Irrigation methods(I)					
I_1. low pressurized drip irrigation	16.02	82.67	7.10	19.18	7.78
I_2 pressurized drip irrigation	14.12	77.20	6.82	18.52	7.55
I_3 flood system	12.39	71.33	6.48	17.96	7.32
SEm±	0.29	1.70	0.14	0.40	0.16
CD (P=0.05)	0.84	5.03	0.42	0.87	0.48
Interaction PXI	NS	NS	NS	NS	NS