

# वार्षिक प्रतिवेदन Annual Report

2013-14



N R C S S



**National Research Centre  
on Seed Spices**

Tabiji, Ajmer- 305 206 (Rajasthan) INDIA



वार्षिक प्रतिवेदन  
Annual Report  
2013-14

N R C S S



**National Research Centre  
on Seed Spices**

Tabiji, Ajmer- 305 206 (Rajasthan) INDIA





**Published by**

**Dr. Balraj Singh**

**Director**

National Research Centre on Seed Spices

Tabiji Ajmer-305 206, Rajasthan, India

**Chief Editor**

Dr. S. N. Saxena (Principal Scientist)

**Editors**

Dr. R.K.Kakani (Principal Scientist)

Dr. R.S.Mehta (Principal Scientist)

Dr. B.K.Mishra (Senior Scientist)

Dr. N.K.Meena (Scientist)

Dr. R. K. Solanki (Scientist)

Dr. Sharda Choudhary (Scientist)

**Hindi Translation**

Dr. S.S. Rathore (Senior Scientist)

**Photographs by**

Sh. M.A. Khan (Asstt. Chief Tech. Officer)

Sh. G. K. Tripathi (Sr. Tech. Assistant)

**Correct citation**

Annual Report 2013-14

National Research Centre on Seed Spices,

Tabiji, Ajmer- 305206 Rajasthan

**Printed at**

NEO BLOCK & Printers

Purani Mandi, Ajmer

Ph 0145-2422291

**Copies : 100**

© NRCSS Tabji, Ajmer 305 206



## CONTENTS

1.	Preface	1
2.	Executive Summary in Hindi	3
3.	Executive Summary	9
4.	Introduction	16
5.	Research Achievements	20
	Crop Improvement	20
	Crop Production	28
	Crop Protection	38
	Basic Science	44
	Social Science	45
	Externally Funded Projects	46
6.	Technology Assessed and Transfer	51
7.	Education and Training	59
8.	Awards and Recognitions	63
9.	Linkages and Collaborations	65
10.	Publications	66
11.	RAC/IMC/IRC Meetings	78
12.	Training/Refresher Course/ Summer / Winter Schools/ Seminars /Conferences/ Symposia/ Workshop Attended by the Scientists	85
13.	Training/Refresher Course/ Summer / Winter Schools/ Seminar /Conferences/ Symposia/ Workshop Organized at the Centre	94
14.	Distinguished Visitors	96
15.	Empowerment of Women	98
16.	Infrastructure Development	99
17.	Personnel	101
18.	Other Information	103





## 2. Preface

The fragrance of Indian seed spices is known world over, the national production of seed spices has gone above 12.33 lakh tonnes. In this last decade area and production of seed spices both have increased significantly. The sincere efforts placed by researchers, developmental agencies, favourable weather and other policy support have been rewarding.

The present Annual Report of National Research Centre on Seed Spices for the year 2013-14 gives a glimpse into the significant achievements made by the centre under different research programmes and other activities. Concerted efforts of scientist have delivered numerous research findings in various aspects which will definitely help in increasing the productivity and quality of seed spices. During the year, total 41.08 quintals quality cumin seed was produced under farmers participatory seed production programme and sold by initiating a Seed distribution fair (Kisan Beej Vitaran Mela) before onset of the *rabi* season in month of September 2013 and from now onwards this event will be organized every year to provide quality seeds to seed spice growers.



Centre has evaluated more than 300 germplasm lines of major seed spices and has also explored new areas for collecting diverse germplasm lines; the total germplasm assemblage has reached to 2094. Besides performing regular experiments of crop improvement, identification of some unique plant types like extra dwarf fennel, extra early genotype in ajwain may prove rewarding in development of ideotypes in future.

Designing of better genotypes is followed by development of efficient production technologies for harvesting the best genetical potential. From the ongoing research programmes at the centre better water management practices following drip system with low pressure and pressurized system, sprinkler, micro sprinkler, mega net system have been tested of which few technologies are ready for recommendation to the farmers. Cultivation of seed spice crops on raised beds coupled with drip and sprinkler system have given excellent results. Use of plastic plug trays for nursery raising of seed spices like fennel, dill, ajwain and celery crops is a pioneer initiative made by the centre. Cropping sequence models specifically for cumin are now available after long testing. Experiments suggesting the critical period for better weed management is underway. Intervention of protected cultivation during these crops is a new concept, coriander cultivation in off-season under green shade net walk in tunnels is a feasible technology for harvesting green leaves under scorching heat of arid and semi arid areas during peak summer month (April to July) .

Sustainability in seed spice production can be achieved by increasing the per unit income of farmers. Looking to the present status of low availability of quality food in the market, concerns have born for having an efficient organic production package for seed spices. Rhizospheric bacterial strains have been isolated which can help in enhancing yield.

Post harvest management is the key to fill the major economic losses happening in seed spice produce management. Post harvest loss minimization is well addressed by the research going on at the centre for testing the affectivity of modified atmospheric packaging.

Biotic stressess are the major factor influencing the yield and quality in seed spices. Besides conducting survey emphasise is also laid on development of better crop protection models taking cultural, chemical and biological formulae. Centre has also contributed high by coming out with two new reports i.e., *Alternaria* blight in fenugreek and *Cenchrus ciliaris* as alternate host of thrips. Cumin wilt management adopting both cultural practices of soil solarisation



and by application of few new identified *Trichoderma* strains have proved effective. Recent studies show that, seed wasp problem in fennel is manageable by adopting intercropping technique and chemical control.

Basic research work going at the centre is focused to address few critical issues, recent studies have shown that application of antioxidants and other agents hasten the germination in cumin significantly. Biochemical characterization of seed spice crops for volatile oil and other metabolites have explored the hidden wealth in these seed spice crops. Moreover, the effort placed by the team of basic sciences is appreciable in bringing an external funded project of National Medicinal Plant Board to study the biochemical properties of major seed spices.

Dissemination of technology is the way out to reach the farmers end and to make worth the investment made for exploring the science behind the technology development. Front line demonstrations of cumin and coriander in area of cultivation have shown significant impact. Centre has placed pain taking efforts in delivering numerous on campus and off-campus farmers training on seed spice production, organization of mega western zone kisan mela during first week of February 2014 has been major ToT activity on part of centre in which more than 8000 farmers participated during 4 days, audio talks, video talks etc from time to time. The far ends of North eastern states, tribal areas and other parts of the country where ever possible the centre has shown their presence and spread the knowledge and science of seed spice production.

The present growth and development of the centre has been possible with the able guidance, encouragement and continuous support received from Dr. S. Ayyappan, Honb'le Secretary, DARE and Director General, ICAR and Dr. N. Krishna Kumar, Deputy Director General (Horticulture), ICAR which I acknowledge with gratitude and respect. I am extremely thankful to Dr. S. K. Malhotra, Assistant Director General (Horti) for his continuous guidance, involvement, active support and inspiration in execution of various activities. I appreciate the efforts made by Dr. Gopal Lal, Dr. S.N. Saxena, Dr. R.K. Kakani, Dr. Y.K. Sharma, and Mr. M. K. Vishal in compiling the report of their respective sections meticulously. I am also thankful to the Publication Committee, Dr. S.N. Saxena, chief Editor and members Dr. R.K. Kakani, Dr. R.S. Mehta, Dr. B.K. Mishra, Dr. N.K. Meena, Dr. R.K. Solanki, Dr. Shardha Choudhary, for their sincere efforts in bringing out the report in time.

At this verge, I feel that the centre has reformed into a strong interdisciplinary team of human resource working hard for developing and catering more and more of seed spice production technologies for betterment of seed spice growers.

Ajmer  
15 June 2014



(Balraj Singh)  
Director



## 2. कार्यकारी सारांश

राष्ट्रीय बीजीय मसाला अनुसंधान केन्द्र ने भारतीय कृषि अनुसंधान परिषद् के अन्तर्गत अपने स्थापना के चौदह वर्ष पूर्ण कर लिये हैं। वर्तमान में केन्द्र में अनुसंधान एवं प्रसार कार्य पाँच विभागों क्रमशः फसल सुधार, फसलोत्पादन, फसल संरक्षण, मूलभूत विज्ञान एवं सामाजिक विज्ञान के अन्तर्गत संचालित किये जा रहे हैं।

### 3.1 अनुसंधान उपलब्धियाँ

#### 3.1.1 फसल सुधार

संदर्भित वर्ष 2012-13 अन्तर्गत दो संकलन कार्यक्रमों द्वारा 87 जननद्रव्य एकत्रित किये गये एवं 300 जनन द्रव्यों का मुख्य कृषि कार्यकी अभिलक्षणों हेतु परीक्षण किया गया।

#### जनन द्रव्य संरक्षण, परीक्षण एवं रख-रखाव

- जनन द्रव्य संग्रहण कार्यक्रमों द्वारा धनिये के 28, जीरे के 30, सौंफ के 15, सोवा के 6, अजवायन के 5, कलौंजी के 2 एवं मैथी का 01 जनन द्रव्य एकत्रित किये गये जिससे केन्द्र का कुल जननद्रव्य 2095 तक पहुँच गया।
- मैथी के 50 जनन द्रव्य परीक्षणों में सर्वाधिक विभिन्नता मुख्यअक्ष पर फली तत्पश्चात् द्वितीयक शाखाओं की संख्या में पायी गयी। न्यूनतम भिन्नता (50 प्रतिशत) पुष्पन दिवसों में पायी गयी।
- धनिये के 60 जनन द्रव्यों के परीक्षण में सर्वाधिक विभिन्नता आधारभूत पर्ण की लम्बाई में पायी गयी। न्यूनतम भिन्नता पादप उँचाई के अभिलक्षण में पायी गयी।
- सौंफ के 50 जनन द्रव्यों के परीक्षण में सर्वाधिक भिन्नता बीजोत्पादन प्रति पादप एवं न्यूनतम पादप उँचाई में देखी गयी।
- जीरे के 20 जनन द्रव्यों के परीक्षण में अधिकतम भिन्नता पादप उँचाई तत्पश्चात् बीज उपज एवं न्यूनतम भिन्नता उपछत्रक प्रतिछत्रक में पायी गयी।
- अजवायन के 84 जननद्रव्यों के परीक्षणांतर्गत सर्वाधिक भिन्नता पादप उपज तत्पश्चात् द्वितीयक शाखा प्रति पादप में पायी गयी। यद्यपि न्यूनतम भिन्नता बीजों की संख्या प्रति उपछत्रक में पायी गयी।
- सेलेरी के 36 जननद्रव्यों के परीक्षण के अन्तर्गत सर्वाधिक भिन्नता द्वितीयक शाखा प्रति पादप तत्पश्चात् बीज प्रति उप छत्रक में पायी गयी वहीं न्यूनतम भिन्नता बीजों के परीक्षण भार में पायी गयी।

#### 3.1.2 बीजीय मसालों का प्रजनन

##### मैथी

- मैथी में समन्वित प्रजाति परीक्षण अन्तर्गत निरन्तर तीसरे वर्ष दो प्रविष्टियाँ ए.एफ.जी.-3 एवं ए.एफ.जी.-4 क्रमशः द्वितीय एवं तृतीय स्थान पर रही एवं राष्ट्रीय मानक हिसार सोनाली की अपेक्षा 7.58 एवं 7.26 प्रतिशत अधिक उपज प्राप्त की।
- ए.एफ.जी.-3 प्रविष्टी को राष्ट्रीय स्तर पर विमोचन हेतु तेइसवीं मसालों में अखिल भारतीय समन्वित परियोजना की कार्यशाला में चिन्हित किया गया।
- मैथी में जननद्रव्य परीक्षण कार्यक्रम के अन्तर्गत 10 प्रविष्टियों को सम्मिलित किया गया। ए.3-43-3 प्रविष्टी द्वारा अधिकतम उपज (23.28 क्व./है.) प्रदान की गयी। तत्पश्चात् ए.3-47-1 द्वारा 22.75 क्व./है. उपज प्रदान की गयी। यह उपज मानक ए.एफ.जी.-2 की उपज 19.3 क्व./है. की अपेक्षा अधिक थी।
- मैथी में उत्परिवर्तन प्रजनन कार्यक्रम अन्तर्गत एम<sub>1</sub> व एम<sub>2</sub> की 160 पंक्तियों को प्रजाति लक्षणों, पादप प्रकार, पादप उँचाई, पर्ण आकार व माप एवं व्यवहार के आधार पर चयनित किया गया। उत्परिवर्तकों का चूर्णिल आसिता एवं झुलसा रोग के प्रति प्रभाव का भी अध्ययन किया गया।
- सीमित जल उपलब्धता की अवस्था में मैथी के तेरह जननद्रव्यों का अध्ययन किया गया। जी X ई परस्पर क्रिया सभी लक्षणों में सार्थक पायी गयी। जनन द्रव्य ए.एफ.जी.-4, बी-2-19 व ए.एम.-203 कठोर वातावरण हेतु उपयुक्त पाये गये।
- आर.ए.पी.डी. चिन्हकों द्वारा मैथी के जनन द्रव्यों का अध्ययन करने पर इसमें निम्न स्तरीय विभिन्नता पायी गयी एवं इन्हें पाँच समूहों में बांटा गया।

##### धनिया

धनिये में 22 अग्रिम उन्नत प्रजातियों का परीक्षण किया गया। एस.के.सी.वी.-09-40 पंक्ति द्वारा उच्च बीज उपज (16.41 क्व./ है.) तत्पश्चात् ए.सी.आर.-139 द्वारा 15.85 क्व./है. उपज प्राप्त हुई।

- धनिये में पुर्नसर्वांग प्रजनन कार्यक्रम में 03 जीन समूह तैयार किये गये। इन जीन समूहों को उच्च उपज एवं अग्रिम पक्वन, छोटे बीज आकार, चार आधारभूत पत्तियाँ, मध्यम उँचाई, बीज संख्या, बीज प्रति छत्रक आदि गुणों के आधार पर बनाया गया।
- आ.ए.पी.डी. चिन्हकों द्वारा 24 जननद्रव्यों का अध्ययन किया गया।



परिणाम स्वरूप 43.08 प्रतिशत भिन्ता पायी गयी एवं जननद्रव्यों को दो समूहों में विभाजित पाया गया।

## जीरा

जीरे के 15 जनन द्रव्यों का परीक्षण अजमेर एवं जैसलमेर जिलों में किया गया। परीक्षण में आर.जेड.-209 एवं जी.सी.-4 को मानक के रूप में उगाया गया। सी.ई.-13 एवं सी.ई.-15 पंक्तियों उपज हेतु उत्तम पायी गयी।

- जीरे में आनुवांशिक भिन्ता बढ़ाने के लिये, 15 उच्च झाड़ीदार पंक्तियों को उगाया गया। आर.जेड.-209 (लम्ब प्रकार) को भी उगाया गया जिससे प्राकृतिक संकरण द्वारा पुनः सयोंग पौधों के समुह प्राप्त हो सके।
- जीरे के जननद्रव्यों को आर.ए.पी.डी. चिन्हकों द्वारा अध्ययन करने पर 15.84 प्रतिशत तक भिन्ता पायी गयी। जबकि प्रचलित प्रजातियों में भिन्ता का स्तर 66.66 प्रतिशत तक था। जननद्रव्यों को चार समूहों में विभाजित किया गया।

## सौंफ

- सौंफ में जननद्रव्य परीक्षण के अर्न्तगत 19 जननद्रव्यों का अध्ययन किया गया। तीन जननद्रव्य क्रमशः ए.एफ.-05-12-1 (31.31 क्व./ है.) ए.जे.-एफ.एन.एल.-2 (30.23 क्व./ है.) एवं एफ-05-7-1 (29.17 क्व./ है) ने राष्ट्रीय स्तर के मानक प्रजातियों की अपेक्षा अधिक उपज प्रदान की। जननद्रव्यों में वाष्पशील तेल की मात्रा का स्तर 0.29 से 2.86 प्रतिशत था।
- रामूलेरीया जनित झुलसा रोग के प्रति एफ.एन.एल.-50 (पी.डी. आई.12.7) एवं ए.एफ-05 (पी.डी.आई. 14.7) जनन द्रव्यों ने प्राकृतिक अवस्था में रोग प्रतिरोधकता दर्शायी।
- स्वपरागण द्वारा सौंफ की बौनी (35 से.मी. ) किस्म का संधारण किया गया। बीजों को भविष्य में फसल सुधार हेतु रखा गया।
- आर.ए.पी.डी. चिन्हकों द्वारा सौंफ के जनन द्रव्यों में 40.37 प्रतिशत भिन्ता देखी गयी एवं जननद्रव्यों को दो समूहों में विभाजित किया गया।

## गौण बीजीय मसाले

### (अजवायन, सोवा, कलौंजी एवं सेलेरी)

- अजवायन में जनन द्रव्य ए.ए.-93 को शीघ्र पकने वाली पंक्ति के रूप में पहचाना गया। यह पंक्ति मात्र 115 दिनों में पकती है। लम्ब प्रकार की 80 से.मी. उँचाई वाली यह पंक्ति रबी एवं खरीफ दोनों ऋतुओं में 55 दिवस पश्चात् पुष्पन प्रदर्शित करती है।

- सोवा (डिल) के जननद्रव्य परीक्षण में 12 जननद्रव्यों का अध्ययन किया गया। इनमें ए.डी.-03-35 ने उत्तम उपज परिणाम दिये। वहीं ए.डी.-67 ने शीघ्र पक्व दर्शाया।
- कलौंजी की 10 उन्नत पंक्तियों में अधिकतम उपज (10.03 क्व./ है.) ए.एन.-21 द्वारा दर्शाया।
- सेलेरी के 13 जननद्रव्यों में ए.सेलेरी.-8 द्वारा अधिकतम उपज (3.05 क्व./ है.) प्राप्त की गयी।

## 3.2 फसल उत्पादन

### 3.2.1 संसाधन संरक्षण एवं उत्पादकता वृद्धि हेतु उपयोग

- जीरे में निम्न दाब बूंद-बूंद सिंचाई पद्धति के उपयोग से पादपों में उत्तम वृद्धि एवं अधिक उपज मानकों में वृद्धि देखी गयी। 20 माइक्रान प्लास्टिक परत द्वारा बीछावन विधि में भी उत्तम पादप वृद्धि एवं उपज देखी गयी। दोनों विधियों के पश्चात् बूंद-बूंद सिंचाई विधि में उत्तम प्रदर्शन पाया गया।
- कलौंजी में उच्च दाब बूंद-बूंद सिंचाई पद्धति द्वारा पादप वृद्धि एवं अधिक उपज देखी गयी जो कि सतही सिंचाई पद्धति से तुलनात्मक अधिक थी। जल संरक्षण कि विभिन्न तकनीकों में 20 माइक्रान प्लास्टिक बिछावन सर्वोत्तम पायी गयी।
- जीरे की खेती को उठी हुई क्यारियों एवं बूंद-बूंद सिंचाई विधि द्वारा उगाने पर उपज में 37.95 एवं 17.72 प्रतिशत वृद्धि पायी गयी। इससे जल उत्पादकता में वृद्धि देखी गयी। उठी क्यारियों में तीन पंक्तियों में बीजाई करने पर उपज में 47.60 व 25.21 प्रतिशत वृद्धि देखी गयी। जल उत्पादकता में 30.39 व 20.68 किग्रा. बीज/ है. से.मी. वृद्धि देखी गयी जो कि सतही एवं चौड़ी क्यारियाँ (150 से.मी.) की अपेक्षा अधिक थी।
- कसूरी मैथी (ट्राइगोनेला कोरनीकुलाटा एल.) में सूक्ष्म बूंद-बूंद सिंचाई पद्धति द्वारा अन्य सिंचाई पद्धतियों की अपेक्षा अधिक उपज एवं जल उत्पादकता देखी गयी। समतल क्यारियों में उपज उठी हुई क्यारियों एवं चौड़ी क्यारियों की अपेक्षा अधिक प्राप्त हुई।
- प्लास्टिक की चलने योग्य सुरंग (80 प्रतिशत आर.डी.एफ.) में धनिये के उत्पादन से उच्च पादप वृद्धि, उपज मानक, उपज एवं शुद्ध लाभ (2,15,807 रु/ है.) नियंत्रित पादपों की तुलना में अधिक प्राप्त हुआ।
- उठी हुई क्यारियों (75 से.मी.) में धनिया, मैथी, सौंफ, अजवायन एवं डिल (सोवा) को उगाया गया। जोड़े में लगी प्रत्येक पंक्ति को उर्वरक देने हेतु बूंद-बूंद सिंचाई की प्रवाह रेखा से जोड़ा गया। अधिकतम उपज क्रमशः 2000.00, 2133.3, 2083.3, 1638.8 एवं 1740.8 किग्रा/ है. प्राप्त हुई। सेलेरी की एकल पंक्ति में



अधिकतम उपज (934.0 किग्रा./है.) प्राप्त हुई।

- मेगा नेट फव्वारा तकनीक द्वारा सिंचाई से मैथी, जीरा, सौंफ, अजवायन, कलौंजी एवं विलायती सौंफ में क्रमशः 38.6, 26.5, 52.8, 11.0, 13.4 एवं 15.9 प्रतिशत अधिक उपज प्राप्त हुई। वहीं सूक्ष्म फव्वारा की उपयोगिता धनिया, सोवा एवं सेलेरी में उत्तम सिद्ध हुई एवं क्रमशः 14.3, 19.6 व 9.6 प्रतिशत अधिक उपज प्राप्त हुई।
- सब्जियों व बीजीय मसालों में उर्वरक के लिये नरम कोयलानुमा खाद (कोकोपीट), कृमिखाद एवं परलाईट के विभिन्न संयोगों का परीक्षण किया गया। सर्वाधिक उत्तम अनुपात 2.5: 1 : 1 पाया गया।
- सौंफ आधारित फसल चक्र में मूंग- सौंफ- हरा चारा तत्पश्चात् मूंग - सौंफ- ग्रीष्म परती चक्र उत्तम पाया गया। जीरा आधारित फसल चक्र में ग्वार- जीरा- हरा चारा फसल चक्र उत्तम पाया गया। उपरोक्त फसल चक्रों से सौंफ तुल्य उपज, शुद्ध प्रतिफल एवं लाभ : लागत अनुपात अधिक प्राप्त हुए।
- बीजीय मसाला फसलों एवं फल वृक्षों का स्थायी एवं लाभकारी फसल तंत्र विकसित किया गया। मैथी ने सर्वोत्तम परिणाम दिये। परिणाम स्वरूप ऑवले व बेर के साथ उच्च मैथी तुल्य उपज प्राप्त हुई।
- बीजीय मसाला फसलों में खरपतवार से प्रतियोगिता हेतु क्रांतिक अवस्था ज्ञात की गई। यह समय क्रमशः धनियें हेतु 56 दिन, अजवायन हेतु 52 दिवस व सौंफ हेतु 51 दिवस पाये गये।

### 3.2.2 बीजीय मसाला फसलों की कार्बनिक खेती

- जीरे एवं धनिये की कार्बनिक खेती की तकनीक विकसित की गयी। धनिये एवं जीरे की अधिक उपज प्राप्त करने हेतु 75 प्रतिशत नत्रजन एवं फास्फोरस की मात्रा, केंचुआ खाद, केंचुआ खाद + एजेटोबेक्टर द्वारा बीज उपचारण एवं पी.एस.बी. का प्रयोग किया गया।
- धनिये एवं जीरे की कार्बनिक खेती में बीमारियों की रोकथाम हेतु बीजोपचार + ट्राइकोडरमा विरडी मृदा में प्रयोग + नीम केक 150 किग्रा./ है. + करंज तेल की फुहार का मिश्रण सर्वोत्तम पाया गया। तदुपरांत बीजोपचार + ट्राइकोडरमा विरडी मृदा प्रयोग + नीम केक 150 किग्रा./है + सल्फर तत्वों का फुहार मिश्रण लाभदायक पाया गया।
- धनिये एवं जीरे में कीटों के प्रबंधन हेतु गंधक तदुपरांत करंज उदरण 1 प्रतिशत एवं एलायल आइसोथायो सायनेट 1 प्रतिशत प्रभावी पाये गये।

### 3.2.3 कटाई उपरांत प्रबंधन

- कटाई उपरांत अध्ययनों द्वारा ज्ञात हुआ कि जीरे एवं सौंफ में कटाई हेतु सूचकांक क्रमशः 145 एवं 181 बीजाई उपरांत दिवस है। उत्तम गुणवत्ता की सौंफ प्राप्ति हेतु सौर आधारित सुखाने की मशीन उत्तम पायी गयी। सौंफ भंडारण हेतु एल्यूमीनियम निर्वात पेकेजिंग सर्वोत्तम पायी गयी।
- रूपांतरित वायुमण्डलीय पेकेजिंग विधि द्वारा सभी बीजीय मसालों की पेकेजिंग करने पर नियंत्रित अवस्था की तुलना में उत्तम परिणाम प्राप्त हुए।

### 3.2.4 पोषण प्रबंधन

- धनिये के मूल क्षेत्र द्वारा प्राप्त 36 जीवाणु पृथक्कारकों का अध्ययन धनिये में वृद्धि हेतु देखा गया। सी.ओ.आर.-27 द्वारा अधिकतम बीज ओज सूचकांक देखा गया। तदुपरांत सी.ओ.आर.-8 एवं सी.ओ.आर. -15 पाये गये। अधिकतम उपज सी.ओ.आर.-8 द्वारा (0.93 ग्रा./ पादप) मापी गयी। इसी प्रकार सौंफ मूल क्षेत्र के जीवाणुओं का पृथक्करण अजमेर, पाली, झालावाड़ एवं कोटा जिलों के मृदा नमूनों में से किया गया।
- धनिये की प्रजाति ए.सी.आर.-1 में नत्रजन हेतु ताड़ना स्तर का अध्ययन किया गया। परिणामों द्वारा ज्ञात हुआ कि नत्रजन के अधिक उपयोग द्वारा कटाई सूचकांक अधिकतम 60 किग्रा./है. नत्रजन प्राप्त हुआ। इसी प्रकार फास्फोरस में यह स्तर 40 किग्रा./है. प्राप्त हुआ।
- मृदा संघनन स्तर में वृद्धि से जीरे में पादप उँचाई एवं शाखाओं की संख्या में कमी आती है यद्यपि संघनन स्तर 1.35 ग्रा. बी.डी. वृद्धि हेतु क्रांतिक है।

### 3.3 फसल संरक्षण

#### 3.3.1 बीज मसाला रोग एवं कीटों का सर्वेक्षण एवं निगरानी

- बीजीय मसाला फसलों में उपस्थित रोगों एवं नवीन उभरते रोगों हेतु राजस्थान में अजमेर, नागौर, जोधपुर, जैसलमेर, कोटा, बांरा, प्रतापगढ़ एवं सवाई माधोपुर व मध्यप्रदेश के मंदसौर जिले में सर्वेक्षण एवं निगरानी भ्रमण किये गये। जीरे में फ्यूजेरियम जनित गलन, अल्टरनेरिया जनित झुलसा एवं चूर्णिल म्लानी रोग पाये गये।
- धनिये में तना, गांठ, चूर्णग्लानि, सौंफ में रामूलेरिया जनित एवं चूर्णिल म्लानी रोग पाये गये। मैथी में चूर्णिल म्लानी एवं मृदुरोमिल आसिता रोग पाये गये। रोगों की तीव्रता मध्यम से अधिक थी।
- बीजीय मसाला फसलों में कीट संकुल में चूषक कीटों की मात्रा अत्यधिक थी। जिनमें प्रचुर रूप से चैपा, जैसिड, सफेद मक्खी,



पर्ण माइनर, थ्रिप्स, हॉपर एवं बग थे।

- बीजीय मसाला फसलों के मुख्य हानिकारक कीटों के प्राकृतिक शत्रु कीट मुख्यतः कॉक्सीनेला, एफीड प्रीडेटर पाये गये। मधु मक्खियाँ परागकण सम्प्रेषक कर्ता पायी गयी। एपीस फ्लोरा इन फसलों पर मुख्यतः पायी गयी।
- अजमेर में सर्वेक्षण के अंतर्गत एक नयी चैपा प्रजाति देखी गयी। इस प्रजाति के चैपा का रंग लाल एवं हरा था। जो कि पूर्व वर्णित चैपा से भिन्न पाये गये।
- जीरे में चैपा एवं थ्रिप्स मुख्य कीट पाये गये। थ्रिप्स की अधिकता प्रारम्भिक वानस्पतिक अवस्था में अधिक पाये गये। धनिये, मैथी एवं सौंफ में चैपा प्रमुख पाया जाने वाला कीट है।

### 3.3.2 रोग एवं कीट प्रबंधन

- ट्राइकोडर्मा के पृथक्कारकों सी.यू.7-01, सी.यू.7-02, सी.यू.3-01 एवं सी.यू. 9-02 के उपयोग द्वारा पादप वृद्धि एवं जीरे के जड़ गलन रोग में रोकथाम हेतु सार्थक प्रभावी पाये गये। सी.यू.7-01 एवं दूसरा सी.यू.-02 के साथ संयोजन पात्रे एवं खेत अवस्था में प्रभावी पाये गये।
- जीरे के जड़ गलन रोग में 20 दिवस तक मृदा सौरीकरण एवं नीम केक + ट्राइकोडर्मा वीरडी लाभकारी पाये गये।
- जीरे के झुलसा रोग के प्रबंधन में मेकोजब के प्रतिस्थापन के रूप में क्लोरोथेलोनील के बाद एजॉक्सीस्ट्रीबीन या प्रोपीयाकोनाजोल के दो छिड़काव प्रभावी पाये गये।
- जीरे एवं अजवायन के भंडारण हेतु भृंग कीटों के नियंत्रण हेतु रूपांतरित वायुमंडलीय पेकेजिंग प्रभावी पायी गयी। जिसमें विभिन्न अक्रिय गैसों का सम्मिश्रण था।
- विभिन्न अ-रसायनिक विधियों में जीरे व अजवायन में भृंग के नियंत्रण हेतु डाइएटोमेसियस अर्थ @ 0.2 प्रतिशत सर्वोत्तम पाया गया। जिससे भृंगों में अधिकतम मृत्यु दर, बीजों को न्यूनतम क्षति एवं सूक्ष्मजीवों की मात्रा न्यूनतम पायी गयी।
- जीरे एवं अजवायन के स्वयं के तेल के अन्तर्भेदन से 1 प्रतिशत भृंगों के प्रति अधिकतम प्रभाव देखा गया।
- सौंफ में वास्प कीट द्वारा बीज में क्षति को सौंफ व सोवा की अन्तर फसल प्रक्रिया (2: 1) द्वारा नियंत्रित किया जा सकता है। इसी प्रकार मृदा में करज खली के प्रयोग (500 किग्रा. /है.) एवं तदुपरान्त 2.0 प्रतिशत करज तेल के छिड़काव से भी वास्प द्वारा बीज क्षति में सुरक्षा मिलती है।
- प्रणालीगत कीटनाशकों के मृदा में उपयोग के कम में क्लोथीयानाडीन @ 1.0 किग्रा का /है. 120 दिवस पर कीटों के

प्रति अधिकतम सुरक्षा देता है।

- सौंफ में बीज मित्र कीट के प्रबंधन में नीम्बोली के सत @ 5 प्रतिशत के छिड़काव प्रभावी पाया गया।

### 3.3.3 नव विवरण

- मैथी में अल्टरनेरिया अल्टरनेटा जनित पर्ण झुलसा रोग प्रथम बार देखा गया।
- थ्रिप्स प्रजाति के बीजीय मसाला फसलों के अतिरिक्त प्रथम बार वैकल्पिक पोषिता देखा गया। यह पोषिता पादप आंजन घास थी।

## 3.4 मूलभूत विज्ञान

### 3.4.1 बीजीय मसालों में गुणवत्ता हेतु जैव रसायनिक रूप रेखण

- धनिये के 19 व मैथी के 16 जनन द्रव्यों का अध्ययन वाष्पशील तेल, जी.सी.एम.एस रूपरेखण, ओलियोरेजिन, फिनोलीक, फ्लेवनाइड्स, कुल आक्सीकारक तत्वों, गेलेक्टोमेनन, सेपानीन व डायोसजेनिन संघटकों हेतु किया गया। मैथी में वसीय अम्लों के एस्टर्स में अत्यधिक भिन्नता पायी गयी।

### 3.4.2 बीज अकुरण वृद्धि

- प्रतिआक्सीकारकों के उपयोग से जीरे में अकुरण प्रतिशतता, जल्द अकुरण, जड़ गलन रोग एवं झुलसा रोग बचाव किया जा सकता है। इन प्रति आक्सीकारकों द्वारा जीरे की पत्तियों एवं जड़ में फिनोल का स्तर भी बढ़ जाता है जो कि पादप आंतरिक सुरक्षा से सम्बंधित कारक है। इन प्रतिआक्सीकारकों के प्रयोग से हानिकारक फफूंदनाशकों एवं रसायनों से बचा जा सकता है।
- जीरे में बीजों को सेलीसिलिक अम्ल (5 माइक्रो मोलर), बीटेन (3.5 माइक्रो मोलर), प्रोलिन (200, 400 एवं 600 माइक्रो मोलर ) बेजोइक अम्ल (100 पी.पी.एम.), एस्कार्बीक अम्ल (100, 300 पी.पी.एम.) एवं पी.वी.पी. (100, 200 पी.पी.एम.) के उपचार से बीजों में 8वें दिन 50 प्रतिशत से अधिक अकुरण देखा गया।
- खेत में जीरे की फसल में बेजोइक अम्ल (100 पी.पी.एम.), एस्कार्बीक अम्ल (200 पी.पी.एम.), पी.वी.पी. (200 व 300 पी.पी.एम.)  $\text{KH}_2\text{PO}_4$  (0.75 एवं 1 प्रतिशत), बीटेन (7 माइक्रो मोलर), पी.वी.पी. (10 प्रतिशत), सिट्रीक अम्ल (300 पी.पी.एम.), प्रोलिन 600 माइक्रो मोलर + बीटेन (7 माइक्रो मोलर ) द्वारा उत्तम परिणाम प्राप्त हुए।
- जीरे की प्रजाति जी.सी.-4 में ग्लायसीन (400 माइक्रो मोलर ), पेक्जी (3 माइक्रो मोलर ), प्रोलिन (200 एवं 400 माइक्रो मोलर) के बाह्य उपयोग से उपज में सार्थक वृद्धि पाई गयी।



### 3.5 सामाजिक विज्ञान

#### 3.5.1 बीजीय मसाला सम्बंधित सूचीबद्धता

- बीजीय मसाला फसलों हेतु शुद्ध व्यापार, उत्पादन क्षेत्र, उत्पादन एवं उत्पादकता, घरेलू एवं अंतरराष्ट्रीय कीमतों हेतु नवीनतम जानकारियाँ एकत्रित की गयी। बीजीय मसाला फसलों के मानचित्र बनाने की प्रक्रिया के अंतर्गत विभिन्न राज्यवार मानचित्र बनाये गये।

#### 3.5.2 तकनीक प्रसार एवं प्रभाव

- प्रदेश के चयनित जिलों में बीजीय मसाला फसलों के उत्पादन तकनीकों पर नो (09) प्रशिक्षण कार्यक्रम आयोजित किये गये। जिनमें 180 किसानों ने भाग लिया।
- जीरे एवं धनिया के खेत पर प्रदर्शनों हेतु सम्पूर्ण पैकेज जिसमें कि उत्तम प्रजाति के बीज, बीजोपचार, खाद एवं खरपतवार नियंत्रक आदि सम्मिलित थे, किसानों को प्रदान किये गये।
- उत्तम बीजों, फफूंदनाशकों, खपतवारनाशियों एवं खाद के संयुक्त प्रभाव से विभिन्न जिलों यथा जोधपुर एवं अजमेर में क्रमशः 56.25 प्रतिशत व 55.81 प्रतिशत वृद्धि पायी गयी। इसी प्रकार बारां जिले में धनिया की ए.सी.आर.-1 प्रजाति की उपज में 37.00 प्रतिशत वृद्धि पायी गयी।
- बीजीय मसाला फसलों में तकनीक प्रदर्शनों के प्रभाव का अध्ययन करने हेतु कुल लाभार्थियों के 10 प्रतिशत का अध्ययन किया गया। लाभार्थियों के ज्ञानस्तर एवं विभिन्न नवतकनीकियों के ग्रहण करने में सार्थक वृद्धि देखी गयी।

#### 3.7 बाह्य वित्त पोषित परियोजनायें

- राष्ट्रीय कृषि नवोन्मेषी परियोजना (एन.ए.आई.पी.-2) मुख्य बीजीय मसालों के घरेलू एवं निर्यात हेतु मूल्य श्रृंखला के अन्तर्गत धनिया कि ए.सी.आर.-1, आर.सी.आर.-41, आर.सी.आर.-435 एवं आर.सी.आर.-456 व मैथी में ए.एफ.जी.-2 एवं ए.एफ.जी.-3 को उत्तम उपज एवं गुणवत्ता हेतु अंकित किया गया।
- बाड़मेर, जैसलमेर, जयपुर, नागौर व अजमेर जिलों में मैथी, जीरा, धनिया के तैतीस प्रदर्शन लगाये गये। समस्त प्रदर्शनों में प्रचलित पद्धतियों की अपेक्षा 17 से 36 प्रतिशत तक अधिक उपज प्राप्त हुई।
- सौर शुष्क यंत्र द्वारा मैथी की हरी फलियों एवं बीजों को सुखाने से अधिकतम गुणवत्ता, रंग आकार एवं स्वाद युक्त फलियों व बीज प्राप्त हुए।

- एन.ए.आई.पी.-4 की परियोजना मसालों की शीतलन पिसाई के अन्तर्गत अध्ययन में पाया गया कि धनिया की प्रजाति ए.सी.आर.-436 एवं सुधा में दर्द निवारक एवं तापरोधिता गुण पाये गये। परिणामों से ज्ञात हुआ कि शीतलन विधि द्वारा पीसा गया धनिया सामान्य पिसाई कि अपेक्षा अधिक प्रभावी पाया गया। आर.सी.आर.-436 प्रजाति अधिक प्रभावशाली पायी गयी। प्रयोग द्वारा यह भी ज्ञात हुआ कि औषधीय गुण शीतलन विधि द्वारा पिसाई उपरांत सामान्य पिसाई कि अपेक्षा अधिक प्रभावकारी होते हैं।
- वर्ष 2012-13 के अन्तर्गत सात बीजीय मसाला फसलों जीरा, धनिया, मैथी, सोवा, अजवायन, सौंफ व कलोंजी का कुल 28 क्विंटल प्रजनक बीज उत्पादन किया गया।
- बीज उत्पादन कार्यक्रम के अन्तर्गत कुल 41.08 क्विंटल जीरे का बीज उत्पादन किया गया।
- जैव प्रौद्योगिकी विभाग की परियोजना जैव नियंत्रकों द्वारा कीट एवं रोग प्रबंधन के अन्तर्गत 19 गाँवों के 187 किसानों को चयनित कर ट्राइकोड्रमा विरडि, वर्टीसीलीयम लेकानी एवं नीम तेल वितरित किया गया। एवं दो दिवसीय प्रशिक्षण कार्यक्रम भी आयोजित किया गया।
- मैथी व धनिया के डस दिशा निर्देशों को प्रकाशित किया गया।
- केन्द्र में पादप प्रजातियों का संरक्षण एवं किसानों के अधिकार पर किसानों के लिये प्रशिक्षण कार्यक्रम आयोजित किया गया।

#### 3.8 तकनीकी हस्तांतरण

- राष्ट्रीय बागवानी मिशन के अन्तर्गत, विभिन्न बीजीय मसालों (मैथी, जीरा, धनिया) के उत्पादन तकनीकों हेतु अजमेर, पाली, झुंझनु, सीकर, बांरा, बाड़मेर एवं जैसलमेर जिलों में प्रदर्शन आयोजित किये गये।
- उन्नत उत्पादन तकनीकों हेतु दो प्रशिक्षण कार्यक्रम पाली एवं झुंझनु कृषि विज्ञान केन्द्रों में आयोजित किये गये। इन प्रशिक्षणों में 136 किसानों ने भाग लिया। संदर्भित वर्ष में केन्द्र में 25 प्रशिक्षण कार्यक्रम आयोजित किये गये।
- केन्द्र ने उत्तर पूर्व के दो राज्यों अरुणाचल प्रदेश एवं असम में अपारम्परिक बीजीय मसाला उत्पाद क्षेत्रों में इनके क्षेत्रफल एवं उत्पादन में वृद्धि हेतु प्रसार प्रशिक्षण कार्यक्रम आयोजित किये गये।
- असम एवं अरुणाचल प्रदेश में धनिया, मैथी, अजवायन व कलोंजी के कुल 220 प्रदर्शन लगाये गये।



- जनजाति उप योजना के अन्तर्गत राजस्थान के तीन जनजाति बाहुल्य जिलों क्रमशः डुंगरपुर, बांसवाड़ा एवं प्रतापगढ़ में बीजीय मसाला फसलों के क्षेत्रफल, उत्पादन में प्रसार हेतु कार्य किये गये।
- कृषि विज्ञान केन्द्र प्रतापगढ़ में इसके अन्तर्गत प्रशिक्षण कार्यक्रम भी आयोजित किया गया।
- जन जाति चयनित क्षेत्रों में कुल 84 प्रथम पंक्ति प्रदर्शन लगाये गये। केन्द्र में तीनों जिलों से कृषक दलों ने पश्चिम क्षेत्र किसान मेले में भाग लिया।

### तकनीक हस्तांतरण हेतु आयोजित किसान मेले एवं अन्य कार्यक्रम

- केन्द्र के प्रांगण में 4-7 फरवरी 2014 को पश्चिम क्षेत्रीय किसान मेले का वृहद आयोजन किया गया। इस मेले का प्रायोजन कृषि एवं सहकारिता विभाग, कृषि मंत्रालय, भारत सरकार द्वारा किया गया। इस मेले में 5500 कृषकों ने भाग लिया। इस मेले में राजस्थान, गुजरात, महाराष्ट्र, हरियाणा, दिल्ली एवं उत्तर प्रदेश से कृषकों एवं अन्य हितलाभार्थियों ने भाग लिया।
- केन्द्र प्रांगण में तीन दिवसीय (सितंबर 28-30, 2013) राष्ट्रीय बीज वितरण मेले का आयोजन किया गया। किसान संगोष्ठियों का आयोजन भी इस मेले के अन्तर्गत किया गया। इस मेले में लगभग 1500 किसानों ने भाग लिया। विभिन्न प्रदेशों से आये किसानों ने इसका लाभ उठाया। अन्य कृषि परिषद् के संस्थानों, निजी कम्पनियों, गैर सरकारी संगठनों ने भाग लिया एवं विभिन्न तकनीकों का प्रदर्शन किया।
- वर्ष 2013-14 के अन्तर्गत संस्थान में लगभग 10000 किसानों एवं विद्यार्थियों ने भ्रमण किया। यह भ्रमणकर्ता विभिन्न राज्यों हरियाणा, गुजरात, उत्तर प्रदेश, हिमाचल प्रदेश, पंजाब, मध्य प्रदेश आदि से सम्बंधित थे।
- केन्द्र से वैज्ञानिकों ने सात रेडियो एवं दूरदर्शन चर्चाओं में भाग लिया।
- संदर्भित वर्ष में केन्द्र के वैज्ञानिकों एवं तकनीकीकर्मियों द्वारा विभिन्न संस्थानों द्वारा आयोजित 6 किसान मेलों में केन्द्र द्वारा विकसित तकनीकों का प्रदर्शन किया।

### 3.8 मानव संसाधन विकास

- मानव संसाधन विकास गतिविधियों के अन्तर्गत संस्थान से तीन वैज्ञानिकों ने सयुक्त राज्य अमेरिका स्थित प्रतिष्ठित विश्वविद्यालयों में सम्बद्धित क्षेत्रों में प्रशिक्षण प्राप्त किया। छः अन्य वैज्ञानिकों ने देश में प्रशिक्षण कार्यक्रमों में भाग लिया।
- केन्द्र में परिषद द्वारा प्रायोजित 10 दिवसीय लघु पाठ्यक्रम, 3-12 अक्टूबर, 2013 को आयोजित किया गया जिसमें विभिन्न संस्थानों से 18 वैज्ञानिकों/प्राध्यापकों ने भाग लिया। संस्थान के वैज्ञानिकों ने वर्ष भर में 50 सेमीनार/कार्यशालाओं/कान्फ्रेंस में भाग लिया।

### 3.9 ढांचागत विकास

- केन्द्र में वैज्ञानिक प्रशिक्षण छात्रावास एवं नव बीज भण्डारण गृह का निर्माण किया गया। पुराने भवनों का नवीनीकरण किया गया। संदर्भित वर्ष में वातावरण हितेषी विधुत व्यवस्था की स्थापना की गयी जिसके अंतर्गत सौर आधारित एल.ई.डी. एवं सी.एफ.एल. रोशनी की व्यवस्था सड़कों/मार्गों पर की गयी।
- केन्द्र में विडियो कान्फ्रेंसिंग कक्ष का निर्माण किया गया। जिससे कान्फ्रेंस, प्रशिक्षण आदि सुलभ हो सके।
- उच्च क्षमता वाली इन्टरनेट व्यवस्था (एन.के.एन.) की गयी।



## 3. Executive Summary

The National Research Centre on Seed Spices under the aegis of Indian Council of Agricultural Research (ICAR) has completed 14 years of its establishment. Research and extension activities of the centre are presently carried out by five scientific sections: Crop Improvement, Crop Production, Crop Protection, Basic Science and Social Science.

### 3.1 Research achievement

#### 3.1.1 Crop Improvement

During the reporting year 87 germplasm lines were collected by two explorations programmes and 300 germplasm lines were evaluated for major agromorphological traits.

#### Germplasm conservation, evaluation and maintenance

- Under exploration programmes, 28 coriander lines, 30 cumin lines, 15 fennel lines, 6 dill lines, 5 ajwain lines, 2 nigella lines and one fenugreek line were collected. After which the NRCSS germplasm assemblage has reached a total of 2094 lines.
- In fenugreek, among 50 germplasm lines maximum variability was found for pods on main axis followed by secondary branches per plant, while minimum was observed for days to 50% flowering.
- In coriander, among 60 germplasm lines maximum variability was recorded for length of longest basal leaf while minimum was for plant height.
- In fennel, among 50 germplasm lines maximum variability was found for seed yield per plant while minimum was observed for plant height.
- In cumin, among 20 germplasm lines maximum variability was seen for plant height followed by seed yield while minimum was observed for umbellate per umbel.
- In ajwain, among 84 germplasm lines maximum variability was found for seed yield followed by number of secondary branches per plant while minimum was observed for days to maturity.
- In celery, among 36 germplasm lines maximum variability was found for secondary branches per plant followed by seeds per umbellate and minimum variability was recorded for test weight.

#### Seed spice breeding

Seed spices breeding programme continued with the conduct of 04 coordinated varietal trials (CVT), 09 genotype evaluation trials, creation and advancement of gene pools, genotype screening for biotic and abiotic stresses and selection cum advancement of breeding material. Besides, molecular characterization of fenugreek and coriander was also carried out using RAPD markers.

#### Fenugreek

- In Fenugreek-Coordinated Varietal Trials conducted for three years, 02 entries namely AFg-3 and AFg-4 ranked second and third for seed yield. gave 7.58 and 7.26 per cent higher seed yield than the national check Hisar Sonali.
- AFg-3 has been identified from Coordinated Varietal Trials for national release by the XXIII AICRP on Spices during Annual Workshop held at IISR, Calicut.
- In fenugreek-genotype evaluation trial, 10 advanced lines were tested A3-43-3 was the highest seed yielder with 23.28 q/ha followed by A3-47-1 with 22.75 q/ha as compared to best check AFg-2 with 19.36 q/ha.
- In fenugreek mutation breeding, 160 lines from M5 and M6 were selected as variants for plant type, plant height, leaf shape & size and growth behaviour. The response of mutants for powdery mildew and *Alternaria* blight incidence were also recorded.
- Thirteen genotypes of fenugreek were evaluated under water limiting conditions. The G x E interaction was found significant for all the characters observed. Genotypes AFg-4, B-2-19 and AM-293 are more suitable for poor environment. While genotypes AFg-3, AFg-6 and AM-413 were more suitable for better environment.
- RAPD analysis of fenugreek germplasm lines revealed a low degree of polymorphism delineating the genotypes into five major groups.



### Coriander

- In coriander-genotype evaluation trial, 22 superior populations were tested in randomized block design. Population, SKCV-09-40 gave highest seed yield of 16.41 q/ha followed by IC-570325 (16.16) and Acr-139 (15.85 q/ha).
- In coriander recombination breeding programme, 03 gene pools created earlier by pooling plants which were early maturing and high yielding; small seed sized; having 4 basal leaf, medium height, higher no. of seed per umbel and higher yield; through sib mating of selected population are being maintained and selections were carried out for genetic improvement.
- RAPD analysis of 24 genotypes of coriander showed 43.08% polymorphism. Cluster analysis delineated the genotypes into two major groups.

### Cumin

- In cumin-genotype evaluation trial, 15 cumin genotypes were tested in randomized block design with two checks RZ-209 and GC-4 at Ajmer and Jaisalmer. CE-13 and CE-15 were found to be promising for seed yield.
- In cumin, for enhancement of genetic variability, 15 superior genotypes (bushy type) were bulked independently with RZ-209 (erect type) to get recombinant populations by natural hybridization. The population is advanced by selecting individual plant from each bulked population.
- RAPD analysis of cumin germplasm showed polymorphism upto 15.84%, whereas polymorphism was high (66.66%) among the released varieties. Cluster analysis delineated the genotypes into four major groups.

### Fennel

- Nineteen superior populations of fennel were tested in randomized block design, three populations namely AF-05-12-1 (31.31 q/ha), AJ-FNL-2 (30.23 q/ha) and AF-05-7-1 (29.17 q/ha) were found superior over check varieties for seed yield. The essential oil content in these populations ranged from 0.29 to 2.86 %.
- Two populations namely FNL-50 (PDI 12.7) and AF-05

(PDI 14.7) were found elite and described resistant against *Ramularia* blight.

- A unique extra dwarf fennel genotype of only 35 cm height was maintained through selfing. Seeds have been preserved for their use in improvement programme.
- RAPD analysis of fennel varieties and germplasm generated 40.37% polymorphism. Cluster analysis delineated the genotypes into two major groups.

### Minor Spices (Ajwain, Dill, nigella and Celery)

- In ajwain, genotype AA-93 was indentified for earliness which matures in 130 days only. This genotype is erect and 80 cm in height and flowered in 55 DAS in both Rabi and Kharif season.
- Among 12 test entries of dill, AD-03-35 gave higher yield than check varieties, while AD-67 showed early maturity as compared to other populations.
- In dill recombination breeding programme, a gene pool is being maintained through close sib mating for maximum introgression of genes within the gene pool.
- Among 10 advance line of nigella, maximum seed yield (10.03q/ha) was recorded in AN-21 as compare to check varieties.
- In celery, 13 selected genotypes were evaluated. Genotype A-Cel-8 gave more yield (3.05 q/ha) compared to checks.

### 3.1.2 Crop production

#### Resource conservation and utilization for higher productivity

- Irrigation through low pressure drip in cumin resulted in highest growth parameters and yield attributes followed by drip irrigation. Mulching with 20 micron plastic sheet exhibited highest yield attributes followed by drip irrigation.
- Irrigation through high pressure drip in nigella resulted in highest yield attributes followed by surface irrigation. Among the various water conservation techniques mulching with 20 micron plastic sheet exhibited highest plant growth parameters and yield attributes of the crop.



- Cumin cultivated on raised bed coupled with drip irrigation not only enhanced the yield of cumin by 37.95 and 17.72 % than surface and micro sprinkler irrigation but also improved the water productivity. Among land configuration treatments tested, sowing of 03 rows of cumin on raised beds enhanced the grain yield by 47.60 and 25.21 % and water productivity by 30.39 and 20.68 kg seed/ha cm irrigation water than flat bed and wider raised beds (150 cm).
- Kasuri methi (*Trigonella corniculata* L.) irrigated through micro sprinkler showed enhanced yield with high water productivity than surface and drip irrigation methods. Sowing of kasuri methi on flat bed enhanced the grain yield and water productivity than raised beds (75 cm) and wider beds (150 cm), respectively.
- Coriander cultivation under plastic walk in tunnel with 80 % RDF was found better for realizing higher growth, yield attributes, yield and net returns of Rs. 2,15,807/-ha over control. Aphid incidence was also minimum as compared to control/ open conditions. Cumin produced under insect proof net walk in tunnels with 80% RDF exhibited higher returns Rs. 61,025/-ha over control.
- Coriander, fenugreek, fennel, ajwain and dill cultivation on raised beds of 75 cm with paired row planting coupled with one drip line for fertigation gave maximum yield of 2000.0, 2133.3, 2083.3, 1639.8 and 1740.8 kg/ha respectively, whereas in celery single row coupled with one drip line on 75 cm raised bed gave maximum yield (934.0 kg/ha).
- Fenugreek, cumin, fennel, ajwain, nigella and anise performed better in mega-net sprinkler and gave 38.6, 26.5, 52.8, 11.0, 13.4 and 15.9 % higher seed yield than the gyro net (micro sprinklers), respectively, whereas gyro net (micro sprinkler) was found better for coriander, dill and celery than the mega net sprinkler as it gave 14.3, 19.6 and 9.6 % higher yield respectively.
- Nursery raising using different combinations of coco peat, vermiculite and perlite in the ration of 2.5:1:1 (v/v) was found best for raising the seedlings of vegetables and seed spices.
- Cropping sequence of Greengram-Fennel-Green manuring followed by Greengram- Fennel-Summer

fallow was found better in fennel based cropping sequence while Cluster bean-Cumin-Summer solarisation followed by Clusterbean-Cumin-Green manuring was found better among cumin based cropping sequences for realising higher fennel equivalent yield, net return and BCR.

- Among seed spices fenugreek association with fruit trees proved highly beneficial which resulted higher coriander equivalent yield with Ber as well as Aonla.
- Critical time for weed competition has been identified in seed spice crops. It was found to be 56 days for coriander, 52 days for ajwain and 51 days for fennel.

#### Organic seed spice cultivation

- Organic seed spice production technology has been developed for coriander and cumin. Application of 75 per cent N&P through vermi compost, enriched vermi-compost +seed inoculation with *Azotobactor* and PSB was found better for realizing higher yield of coriander and cumin.
- Diseases in cumin and coriander can effectively be controlled with the application of seed treatment + soil application of *Trichoderma viridie* + soil application of neem cake @ 150 kg ha + foliar spray of Karanj oil followed by seed treatment + soil application of *Trichoderma .viridie* + soil application of neem cake @ 150 kg ha + foliar spray of Sulphur compounds.
- Spray of sulphur compound of Karanj extract-1% followed by application of Allylisothio cynate-1 % is effective for control of insect pest in coriander and cumin.

#### Post harvest management

- Post harvest studies resulted harvesting indices of 115 and 181 DAS in cumin and fennel respectively. Solar dryer was found best to obtain qualitative and quantitative recovery in fennel. Aluminum vacuum packaging was found best to increase shelf life during storage of fennel .
- Modified Atmospheric Packaging with CO<sub>2</sub> alone, N<sub>2</sub> alone, O<sub>2</sub> alone, vacuum and various combinations over control conditions was found better than normal storage conditions in all seed spice crops.



### Nutrient management

- Thirty six coriander rhizospheric bacterial isolates were screened for their ability of growth promotion. Treatment Cor-27 gave highest response by increasing seed vigour index followed by Cor-8 and Cor-15 over control. Maximum seed yield (0.93 g/plant) was recorded with Cor-8 which was at par with Cor-27 (0.92 g/plant). Similarly, rhizospheric bacteria were isolated from fennel plant and soil samples collected from Ajmer, Pali, Jhalawar, and Kota districts of Rajasthan.
- Threshold level of N requirement of coriander var. ACr 1 was assessed. Yield attributes and nutrient uptake increased with higher doses of N, whereas harvest index was highest with 60 kg Nitrogen, however, tap root length and leaf angle decreased with increase in Nitrogen. Similarly, threshold level of P requirement of coriander var ACr 1 was found (Ajmer Coriander-1) 40 kg P ha<sup>-1</sup>.
- The experiment on cumin for soil compaction stress indicated that plant height and number of branches decreased with increase soil compaction. However, compaction of BD 1.35 g cm<sup>3</sup> is critical for the growth.

### 3.1.3 Crop Protection

#### Survey and surveillance

- Survey and surveillance of existing and emerging diseases of seed spices was conducted in Ajmer, Nagaur, Jodhpur, Jaisalmer, Kota, Baran, Pratapgarh, and Sawai Madhopur districts in Rajasthan and Mandsaur district in Madhya Pradesh. *Fusarium* wilt, *Alternaria* blight and powdery mildew in cumin, stem gall and powdery mildew in coriander, *Remularia* blight and powdery mildew in fennel, powdery mildew and downy mildew in fenugreek were recorded in seed spice growing areas in moderate to severe form.
- Sucking pests comprises the major pests complex of seed spice crops. Major sucking pests associated with seed spices crops were identified to be aphids, jassids, white fly, leaf minor, thrips, hoppers and bugs and were observed on crop from early stage to seed formation/maturation stage.
- Other important pests were seed wasp, jassids, leaf

miner, and hoppers. Among natural enemies of pests, predators *Coccinells*, aphids, parasitoids were most abundant. Honey bees were chief pollinators of crops and *Apis florea* was maximum visitor on these crops.

- During the survey of insect pests of seed spice a new aphid species of red and green colour was found in area of village Rampura and Ajgara of Ajmer district.
- In cumin, aphids and thrips constitute major pests species. Thrips population was found more active in early vegetative stages up to January month. Aphids constitute major pests of coriander, fennel and fenugreek crops and were found active from 4 to 13<sup>th</sup> standard week.

#### New reports

- *Alternaria* leaf blight caused by *Alternaria alternata* in fenugreek (*Trigonella foenum-graecum*) was reported first time in fenugreek at NRCSS experimental field.
- A new alternate host of thrips spp. has been identified. *Cenchrus ciliaris* commonly known as anjan grass or buffelgrass was found an alternative host during off season of seed spice crops.

#### Disease and pest management

- *Trichoderma* isolates viz. Cu7-01, Cu7-02, Cu3-01 and Cu9-02 showed significant efficacy against wilt disease of cumin and enhanced the growth characters as compared to untreated control. Comparatively, maximum reduction in wilt disease and higher vigour index was observed with the application of isolates Cu 7-01 and combination of Cu7-01 + Cu7-02 under pot and field conditions.
- Soil solarization for 20 days and application of neem cake + *Trichoderma viride* was found effective in management of wilt disease in cumin (*Cuminum cyminum*).
- Application of chlorothalonil followed by two sprays of azoxystrobin or propiconazole could be an effective fungicide for the management of cumin blight.
- Modified Atmospheric Packaging (MAP) was found highly effective for control of beetle population in cumin and ajwain seeds using different inert gases



alone and in combinations as a filler in aluminium foil of 1000 micron gauge for control of *Lasioderma serricorne* beetle.

- Among non-chemical method for controlling beetle population in both cumin and ajwain seed, diatomaceous earth @ 0.2% showed maximum mortality of beetle, minimum damage to seeds and low microbial loads. Interestingly, impregnation of 1.0% w/v own seed oil on cumin and ajwain seed resulted maximum protection against beetle population.
- Seed wasp damage in fennel was reduced significantly (3.18%) by inter cropping of fennel with dill in ratio of 2:1 . Soil application of karanj meal @ 500kg/ha and subsequent spray of karanj oil @ 2.0% showed maximum protection against seed wasp damage.
- Application of systemic granular insecticide as soil incorporation at different time of sowing showed that Clothianidin @1.0 kg ai/ha at 120 DAS gave maximum protection (0.89%) against pest.
- Management of seed midge (*Systole albipennis* Walker) in fennel was best achieved by foliar spray and application of Neem Seed Kernel Extract (NSKE) @ 5.0%. However, maximum yield of 25.11 q/ha was obtained in application of Deltamethrin 0.003%.

### 3.1.4 Basic Sciences

#### Biochemical profiling

- Nineteen genotypes of coriander and 16 genotypes of fenugreek were evaluated for volatile oil content, GC-MS profiling, oleoresin content, total phenolic content, total flavonoid content, total antioxidant content, galactomannan content, saponine and diosgenine content.
- Fatty acid methyl esters of fenugreek showed large variation between genotypes .

#### Seed germination enhancement

- Effect of antioxidants (AO) on germination percentage, mortality at 30 DAS due to wilt disease, at 60 DAS due to blight disease and 100 DAS due to repeated wilt and blight disease was significant. Plant defense related biomolecules, total phenol and flavonoids were found in

leaf and root tissues. These AO can be effective bio-alternates for harmful fungicides and chemicals.

- Seed priming of cumin with selected chemicals including PGRs and antioxidants showed germination initiation on 5th DAI under *in vitro* conditions.
- In cumin, treatments of Salicylic Acid 5  $\mu$ M, Betain HCl 3, 5  $\mu$ M, Proline 200, 400 and 600  $\mu$ M Benjoic Acid 100 ppm, Ascorbic Acid 100, 300 ppm and PVP 100, 200 ppm showed more than 50% germination on 8th DAI.
- In cumin under field conditions, treatments of Benjoic Acid 100 ppm, Ascorbic Acid 200 ppm, PVP 200 & 300 ppm, KH<sub>2</sub>PO<sub>4</sub> 0.75% & 1.0%, Betain hydrchloride 7  $\mu$ m, PEG (8000) 10% & 20%, Citric acid 300 ppm, Proline 600  $\mu$ m + Betain hydrchloride 7  $\mu$ m showed better results as compare to control.
- Exogenous application of Glycine 400 uM, Paczee 3uM, Proline 200uM, Proline 400uM resulted in significant increase in seed yield of cumin genotype GC 4.

### 3.1.5 Social Sciences

#### Seed Spices Information cataloguing

- A module has been developed to access the information on domestic and international prices of seed spices and other spice crops, net trade of the seed spices, recent data on area, production and productivity of states and competitive crops. In the event of preparing seed spice atlas, map has been created for the respective state .

#### Technology dissemination and Impact

- Nine training programmes on production technology of seed spices were conducted in selected districts covering 180 participants in the cropping season.
- Demonstrations were conducted on cumin and coriander. The full package of practices was given as intervention comprising improved variety, seed treatment and chemical weed management.
- Increase in yield due to combined effect of seed, fungicide, weedicide and fertilizers in Ajmer and Jodhpur districts of Rajasthan for cumin crop was 56.25 % and 55.81 %, respectively. Similarly, Increase in yield of coriander in Baran district of Rajasthan was 37.00 % higher in RCr-436.



- Impact analysis of technologies demonstrated was done by selecting 10% of the total beneficiaries in Ajmer, Jodhpur and Baran districts of Rajasthan. A significant increase in both, knowledge level and adoption level for cumin and coriander production technologies were found in all three districts.

### 3.1.6 Externally funded projects

#### National Agricultural Innovation project (NAIP)

- In a NAIP project on, value chain in major seed spices for domestic and export promotion, coriander varieties namely ACr-1, RCr-41, RCr-435, and RCr-436 and fenugreek varieties AFG-1, AFG-2 and AFG-3 were identified for higher yield and quality.
- Thirty three demonstrations in coriander, fenugreek and cumin were carried out with the farmers of Ajmer, Barmer, Jaisalmer, Jaipur and Nagaur districts and the yield increased by the given interventions was in the range of 17 to 36 % over local practices.
- Performance of solar dryer for drying of green pods and grain of fenugreek was better, which exhibited maximum recovery percent with better colour, texture and taste.
- In another NAIP project on cryogenic grinding of seed spices, it was reported that seed extracts of coriander genotypes, RCr 436 and Sudha showed considerable analgesic and antipyretic activities. Results indicated that seed extract of cryo ground seeds were more effective than non-cryo ground seeds and RCr 436 was more effective than genotype Sudha. It is concluded that medicinal quality of coriander and similar herbs can improve significantly by adopting cryogenic grinding technology in ayurveda and other natural therapies for various ailments.
- Twenty eight quintal breeder seeds of eight seed spice crops namely cumin, coriander, fennel, fenugreek, dill, ajwain and nigella were produced during 2012-13. Under seed production programme, a total of 41.08 quintal of cumin seeds have been produced.

#### Department of Biotechnology

- In a DBT funded project on management of pest and diseases of seed spices using bio control products, 187 farmers of 19 villages in 5 development block were selected and given *Trichoderma viride*, *Verticillium lecanii* and Neem oil.
- A two days Training to the farmers was also organized at centre for application of bio control agents for pest and diseases management in seed spices.

#### Under PPV & FRA (DUS)

- Published DUS guidelines of coriander and fenugreek.
- A farmers' training programme on Protection of Plant Varieties and Farmer's Rights was organized at the NRCSS sponsored by Protection of Plant Varieties & Farmer's Right Authority, Govt. of India, New Delhi.

### 3.2 Transfer of technology

#### On campus and off campus Training programmes and FLD's

- The centre is also involved in transfer of proven technologies by conducting training programmes and demonstration trials of new varieties and production technologies.
- Under National Horticulture Mission, frontline demonstrations on improved production technology of fenugreek, cumin and coriander were conducted at Ajmer, Pali, Jhunjhunu, Nagaur, Sikar, Baran, Barmer and Jaisalmer districts of Rajasthan.
- Two farmer's training programmes were also organized at KVK, Jhunjhunu (Rajasthan) and KVK, Pali (Rajasthan) where 136 farmers participated and they were provided with the literature on improved seed spice production technology.
- During the reporting year a total of 25 in house farmer's training were organized at NRCSS.

#### Technology dissemination in NEH and TSP areas

- NRCSS has initiated technology transfer activities in North Eastern Hill region covering two states namely Arunachal Pradesh and Assam for crop diversification in favour of seed spices in view of enhancing area and production of seed spice in unconventional areas of



- NEH region. In both the training programmes, 110 farmers (55 at Pashighat and 55 Kahikuchi) participated.
- In addition to this, 220 demonstrations (110 in Arunachal Pradesh and 110 in Assam) on coriander, fenugreek, ajwain and nigella were given to farmers for testing the feasibility and performance of seed spices in NEH region.
- Under Tribal Sub Plan (TSP), NRCSS initiated the work in three district of Rajasthan viz., Dungarpur, Banswara and Pratapgarh for crop diversification in favour of seed spices for enhancing area and production of seed spice in tribal belt of Rajasthan. Three preliminary farmer's training on Unnat Bijya Masalo Ki Kheti were conducted with the help of KVK, Dungarpur; KVK, Banswara and KVK Pratapgrah.
- In tribal area, a total of 84 demonstrations (FLDs) were laid out. Technological interventions in the form of FLDs given were improved varieties, line sowing, seed treatment and recommended POP.
- Three exposure trips of farmers of Dungarpur, Banswara and Pratapghar were organized at NRCSS Research Farm and to attend Regional Krishi Vigyan Mela-2014 (Western Zone) at NRCSS, Ajmer.
- During 2013-14 more than 10000 famers, students from different institutes, mainly from Rajasthan, Gujarat, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Madhya Pradesh, Himachal Pradesh, Jharkhand and Maharashtra visited the centre under various training and visit programmes.
- Scientists of NRCSS delivered more than 7 radio and TV talks on topics related with seed spices.
- During 2013-14 team of scientist and technical staff of NRCSS exhibited seed spice technological packages in six Kisan Mela organized by different agriculture institutions.

### 3.3 Human Resource Development

- Under HRD activities three scientists from NRCSS visited reputed Universities of USA for advance training in relevant fields while six other scientists attended training programmes within India.
- One ICAR sponsored short course was organized during 3-12 October in which 18 scientists/University teachers have participated. Scientists of NRCSS attended more than 50 Seminar/symposium/workshop/conferences across the India during reporting period.

### Kisan mela's and other events for technology dissemination

- Western Zone Krishi Vigyan Mela-2014 was organized in collaboration with Department of Agriculture and Cooperation, Ministry of Agriculture, GOI during 4-7 February, 2014 at NRCSS. In this mega event about 5500 farmers, farm women, students and other stake holders from states of Rajasthan, Gujarat, Maharashtra, Madhya Pradesh, Haryana, Delhi, and Uttar Pradesh participated.
- NRCSS has organized three days (September 28-30, 2013) National Seed Distribution Kissan Mela and Kissan Sangosthi. About 1500 farmer's precipitated from Rajasthan, Bihar, Maharashtra and Gujarat. Quantity seeds of various seed spice crops were sold. Many ICAR Institutes, SAU's state departments, private companies and NGO's participated and displayed their technologies.

### 3.4 Infrastructure Development

- Completion of the building of scientists training hostel, new seed store, renovation work of old office building and stores, installation of environment friendly Solar CFL and low consumption LED 20W street lights in the campus roads have been done during 2013-14.
- A new state-of-art Videoconferencing cell had been established in the National Research Centre on Seed Spices for conferencing, teaching and information dissemination. NRCSS received NKN facility of high bandwidth internet connectivity through Optical Fiber Cable (OFC).



## 4. Introduction

India is known as the 'Land of Spices' and is the largest producer, consumer and exporter of spices and spice products. Spices are nature's gift to humankind. Spices not only add flavour and taste to our food but also enhance keeping quality and medicinal values of food. Spices have a profound influence on the course of human civilization. They permeate our everyday life, provide succor, cure and relax us. Ancient civilization from Egypt, Arab and Rome made extensive use of spices, not only to add flavour to foods and beverages, but as medicines, disinfectants, incenses, stimulants and even as aphrodisiac agents. Non leafy parts (e.g. bud, fruit, seed, bark, rhizome, and bulb) of spices plants were used flavouring or seasoning agents to foods and beverages, and as herbal medicines. Out of the 109 spices listed by the International Organization for Standardization (ISO), India produces as many as 63 owing to its varied agro-climatic regions. Almost all the states and Union territories (UTs) of the country grow one or the other spices. It is a source livelihood and employment for large number of people in the country, both for rural population, who grow them, and the urban population, who process and trade in them.

Out of the total 63 spices grown in India, 20 are classified as seed spices with 36 per cent share in area and 17 per cent share in production of total spice in India. Main seed spices of India are coriander, cumin, fennel, fenugreek, dill, ajwain, celery, anise, nigella and caraway.

Seed spice crops are extensively cultivated in the arid and semi arid region of India during rabi season covering an area of 13.95 lakh ha with production of 12.34 lakh tones annually. In India, major area covered under different seed spices is 5.47 lakh ha in coriander, 5.94 lakh ha in cumin, 0.93 lakh ha in fenugreek, 0.99 lakh ha in fennel and 0.35 lakh ha in ajwain with their production in the country is 5.28, 3.94, 1.12, 1.42 and 0.26 lakh tones respectively. The productivity of coriander, cumin, fenugreek, fennel and ajwain was 9.63, 6.63, 12.12, 14.33 and 7.57 q/ha respectively. The area, production and productivity of seed spices for the year 2012-13 are present in Annexure I.

The prevailing world wide demand for seed spices is more than 200000 tones, of which India alone contributes 188550 tonnes annually (2012-13) valued at Rs. 170600

lakhs. India is exporting only 15.28 per cent of its production. If our consumption level remains same then to meet global demand and to retain our prime position as seed spices export we have to double our production within five year period. This is a great challenge for us as other countries like Bulgaria for coriander, Syria for cumin, Egypt for fennel, Morocco for fenugreek are competing with higher yield per unit area.

National Research Centre on Seed Spices, Tabiji, Ajmer came into existence on 22 April 2000 as per the recommendation of the working group of Department of Agricultural Research and Education which approved establishment of National Research Centre on Seed Spices, Ajmer during IX five year plan. Thus, this institute was set up with a broad-based framework to address diverse agricultural issues related to water and land resources management, crop improvement, crop protection, agro-processing and socio-economic aspects in a holistic manner for enhancing research capacity and for providing a backstopping for improvement in productivity, sustainability and quality with reference to export value of seed spices which play an important role in national economy. The Centre has now completed a decade and has achieved many major achievements which have left a strong impression among all the stakeholders involved with seed spices and has been successful in ensuring an increase in the income of seed spices growing farmers, provide good produce to the consumers as well as raise the profit of all the stakeholder which in turn has fulfilled the dream of earning more foreign exchange in the country.

### 4.1 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° 35' 39" E to 74° 36' 01" longitude and 26° 22' 12" to 26° 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 dSm<sup>-1</sup>



and 0.15 to 0.23% organic carbon, available N 178.5 kg ha<sup>-1</sup> (low), P<sub>2</sub>O<sub>5</sub> 12 kg ha<sup>-1</sup> (medium), K<sub>2</sub>O 85 kg/ha<sup>-1</sup> (low), Ca 214.7 kg ha<sup>-1</sup> (high), Mg 258 kg ha<sup>-1</sup> (medium), S 27 kg ha<sup>-1</sup> (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°C during January and 42-45°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 Annexure IV.

#### Mandate

- To conduct basic, strategic and applied research to

#### Agro meteorological data for the year 2012-13

Month	Temperature (°C)		Relative Humidity (%)		Rainfall (mm)
	Minimum	Maximum	At 8.30	At 17.30	
April, 2011	36.90	25.20	22.63	10.43	0.0
May, 2011	28.79	39.66	41.28	24.83	30.2
June, 2011	29.07	39.05	71.93	52.81	14.4
July, 2011	27.07	36.29	83.28	64.72	78.0
August, 2011	24.79	30.12	88.41	85.34	476.0
Sept, 2011	24.55	31.67	88.38	86.45	111.0
Oct, 2011	21.14	34.22	52.34	37.45	0.0
Nov, 2011	12.93	29.36	57.50	45.25	0.0
Dec, 2011	7.31	26.24	61.03	51.00	0.0
Jan, 2012	5.31	22.86	70.48	52.28	10.0
Feb, 2012	10.77	24.25	76.19	61.96	18.0
March, 2012	14.34	32.53	42.66	38.59	0.0

enhance production, productivity and quality of seed spices with reference to export and domestic demand

- To serve as the national repository of information on seed spices 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

#### Mandate crops: Presently following ten seed spice crops are the mandate crops

- Coriander (*Coriandrum sativum* L.)
- Cumin (*Cuminum cyminum* L.)
- Fennel (*Foeniculum vulgare* Mill.)
- Fenugreek (*Trigonella foenum-graecum*, *Trigonella corniculata* L.)
- Ajwain (*Trachyspermum ammi* Sprague)
- Dill (*Anethum graveolens* L., *Anethum sowa* Kurz.)
- Nigella (*Nigella sativa* L.)
- Anise (*Pimpinella anisum* L.)



9. Celery (*Apium graveolens* L.)
10. Caraway (*Carum carvi* L.)

**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.

**FINANCIAL OUTLAY**

HEAD	PLAN		NON- PLAN	
	RE 2013-14	Expenditure	RE 2013-14	Expenditure
Establishment	0.00	0.00	310.00	291.54
TA	2.00	2.00	2.00	1.99
Other charges including equipment	21.00	21.03	13.70	13.36
Information Technology	10.00	10.00	0.00	0.00
Library Books & journals	5.00	5.00	0.00	0.00
Works	13.00	12.83	0.00	0.00
HRD	10.00	10.00	0.00	0.00
Furniture & Fixture	0.00	0.00	2.00	2.00
Total Rsch & opnl expenses	70.00	70.00	35.00	34.97
Total Admn expenses	55.00	54.97	40.00	40.00
Guest House - Maintenance				
Other Miscellaneous	0.00	0.00	2.00	2.00
<b>Total</b>	<b>186.00</b>	<b>185.83</b>	<b>404.70</b>	<b>385.86</b>

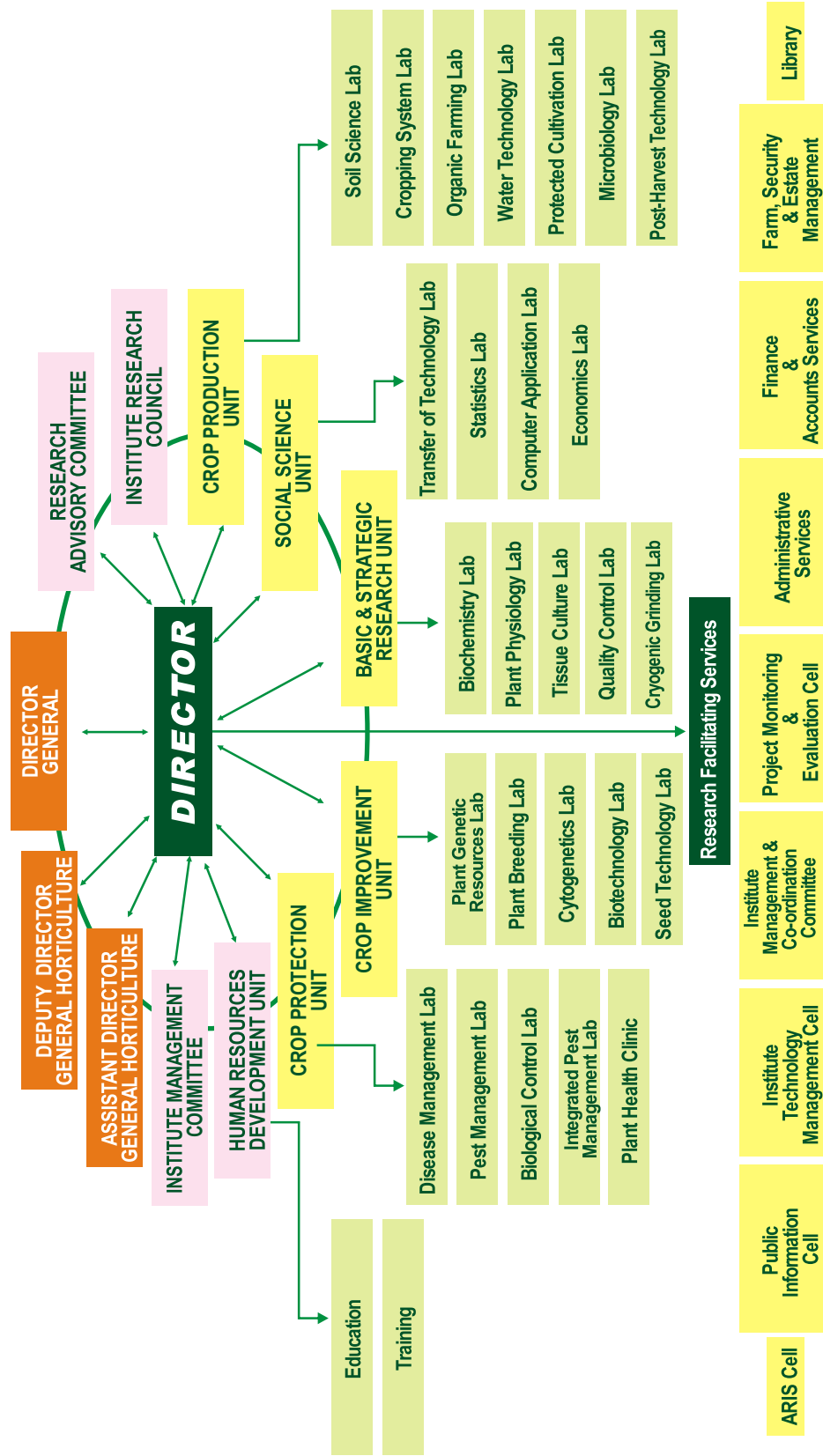
\* Value in lakh

**STAFF POSITION on 31-3-2013**

Grade	Sanctioned	Filled	Vacant
Scientific	20	18	2
Technical	8	7	1
Administration	11	6	5
Supporting	2	2	0
<b>Total</b>	<b>41</b>	<b>33</b>	<b>8</b>



**ORGANOGRAM OF NATIONAL RESEARCH CENTRE ON SEED SPICES**



## 5. Research Achievements

### 5.1 Collection, evaluation and documentation of plant genetic resources of seed spices

#### 5.1.1 Management of plant genetic resources of seed spices crops

##### Germplasm collection

Two explorations were conducted during the year. In the first exploration, Dr. R. S. Meena visited Mehsana, Unjha, Patan and Gandhinagar area during 23-25 March, 2013 and collected 30 lines of cumin, 15 lines of fennel, 4 lines of dill, 5 lines of ajwain and one of fenugreek. The second exploration was conducted by Dr. R. S. Mehta to the North Eastern India particularly, Nagaon, Golaghat, Karbi-Anglong districts of Assam during 5-14 April, 2013. He collected 28 lines of coriander, 2 lines of dill and 2 of nigella. Thus a total of 87 lines were added to NRCSS germplasm assemblage, making it to 2094 (Table 5.1).

**Table 5.1 Total germplasm assemblage at NRCSS**

Crop	NRCSS Collection			NAGS	
	Indigenous	Exotic	Lost	Available	Holding
Cumin	100	7	-	107	247
Coriander	169	3	27	145	518
Fenugreek	82	59	6	135	733
Fennel	118	3	75	46	297
Ajwain	99	1	9	91	100
Dill	106	5	3	108	111
Nigella	21	3	-	24	24
Celery	36	-	-	36	36
Anise	18	-	-	18	18
Caraway	8	2	8	2	10
<b>Total</b>	<b>759</b>	<b>83</b>	<b>128</b>	<b>714</b>	<b>2094</b>

##### Evaluation and maintenance of germplasm

All the crop curators are maintaining germplasm through sib-mating and evaluating core set of germplasm as per descriptors. This year multilocation evaluation had also been carried out for 60 lines of coriander, 50 lines of fennel, 50 lines of fenugreek and 20 lines of cumin.

##### Fenugreek

Fifty germplasm lines of fenugreek were evaluated in Augmented Block Design with 5 blocks and 5 checks. The checks were Hisar Suverna, Hisar Sonali, RMT-361, RMT-1 and AFG-3. Maximum variability was found for pods on main axis followed by secondary branches per plant while minimum was recorded for days to 50% flowering (Table 5.2)

**Table 5.2 Variability recorded in fenugreek germplasm lines**

Characters	Mean	Range	(GCV%)	(PCV%)
Days to 50% flowering	54.78	52.88-62.88	3.139	3.324
Primary branches/ plant	6.19	3.71-9.47	15.127	19.833
Secondary branches / plant	3.57	1.18-5.98	22.969	28.247
Plant height (cm)	60.96	43.83-68.47	5.806	8.144
Pods on main axis	16.11	9.63-76.59	51.234	52.493
Pods/plant	50.23	22.43-81.03	18.255	21.365
Pod length (cm)	10.37	8.89-12.58	3.917	8.000
Seeds /pod	15.46	7.18-19.30	8.356	12.313
Test weight (g)	12.67	4.12-18.41	14.640	19.400
Seed yield /plant (g)	6.05	1.39-13.99	33.630	38.061

##### Coriander

Sixty germplasm lines of coriander were evaluated in Augmented Block Design with 6 blocks and 5 checks. The checks were Hisar Anand, Hisar Sugandh, RCr-728, RCr-436 and ACR-1. Maximum variability was found for length of longest basal leaf followed by number of basal leaves while minimum was recorded for plant height (Table 5.3).

**Table 5.3 Variability recorded in coriander germplasm lines**

Characters	Mean	Range	(GCV%)	(PCV%)
No. of basal leaves	5.36	2.7-10.6	35.88	36.52
Length of longest basal leaf	20.61	7.7-47.7	38.53	39.23
Primary branches/ plant	7.54	3.8-11.3	13.89	16.36
Secondary branches / plant	12.76	6.0-22.8	23.83	25.58
Plant height (cm)	77.96	13.1-49.4	13.06	13.61
Umbels /plant	27.74	14.7-59.4	27.32	28.8
Umbelletes/ umbel	5.49	3.9-9.1	14.49	15.67
Seeds / umbellete	8.2	5.4-12.6	16.89	18.37
Test weight (g)	12.43	7.2-17.8	18.7	18.94
Seed yield / plant (g)	5.83	2.0-12.2	32.05	38.31

##### Fennel

Fifty germplasm lines of fennel were evaluated in Augmented Block Design with 5 blocks and 5 checks. The checks were AF-1, RF-101, RF-125, RF-143 and GF-02. Maximum variability was found for seed yield per plant followed by umbels per plant while minimum variability was recorded for plant height (Table 5.4).



Table 5.4 Variability recorded in fennel germplasm lines

Character	Min	Max	Mean	CV (%)
Primary branches / plant	5	10.2	6.4	16.3
Secondary branches/ plant	8.5	45.6	18.5	37
Plant height (cm)	106.5	189.6	148.1	10.1
Umbels /plant	13.5	103	28.2	45
Umbellates/umbel	16	46.2	25.6	17.4
Seeds/ umbellate	15	36	26.1	16.5
Test weight (g)	4.6	10.7	6.7	16.3
Seed yield/plant (q/h)	0.02	7.2	2.4	72.3

### Cumin

Twenty germplasm lines of cumin were evaluated with 2 checks. The checks were GC-4 and RZ-209. Maximum variability was found for plant height followed by seed yield while minimum was observed for umbellate per umbel (Table 5.5).

Table 5.5 Variability recorded in cumin germplasm lines

Character	Min	Max	Mean	CV (%)
Days to 50 % Flowering	72.00	80.00	75.59	8.40
Primary branches per Plant	5.10	6.80	5.71	4.79
Secondary branches per Plant	7.90	12.56	10.26	19.35
Plant height (cm)	22.60	37.45	30.92	75.42
Umbels per Plant	15.46	25.67	20.62	39.54
Umbellates per Umbel	4.78	5.78	5.17	1.70
Seeds per Umbel	20.41	27.48	23.81	21.98
Days to maturity	112.00	123.00	117.86	7.05
Test weight (g)	3.89	4.54	4.12	7.86
Plot yield (g)	12.61	51.70	28.88	55.60

Table 5.6: Variability recorded in ajwain germplasm lines

S.No.	Characters	Mean	Range	PCV (%)	GCV (%)	
1	Plant height at Harvest (cm)	116.25	85.06	140.72	10.61	7.63
2	Days to 50 % flowering	93.37	56.39	149.39	12.71	11.20
3	Primary branches/Plant	16.95	13.06	21.26	12.52	9.81
4	Secondary branches/Plant	229.74	134.14	324.61	22.68	18.82
5	Umbels /Plant	223.60	97.98	339.12	22.65	18.52
6	Umbellates/Umbel	16.94	10.82	22.96	16.95	8.37
7	Seeds/Umbel	357.03	195.34	614.08	25.88	15.59
8	Diameter of main umbel (cm)	5.33	4.11	6.86	14.06	9.97
9	Days to 75 % maturity	161.58	113.7	174.17	5.07	4.97
10	Seed yield/Plant (g)	9.93	2.27	17.32	37.51	28.65
11	Test Weight (g)	0.73	0.48	1.40	21.29	20.70
12	Harvest index (%)	40.34	26.15	56.55	18.02	15.36

### Celery

Thirty six germplasm lines were evaluated for all the major descriptor traits. Ample amount of variability was found in the germplasm set. High range of variation was observed for plant height (44 cm to 90.2 cm), umbel per plant (72.7 to 36.20), and yield per plant (7.96 g to 91.32 g). Diversity index was estimated among the thirty six lines, all the germplasm lines were falling in the groups as per their geographical areas of collection.

Table 5.7 Variability recorded in celery germplasm lines

Character	Mean	Min.	Max.	Standard Deviation	CV%
Plant height (cm)	72.06	44.00	90.20	10.06	79.88
Primary Branches/Plant	6.92	5.33	9.30	0.82	74.37
Secondary Branches /Plant	10.78	7.00	12.30	1.15	87.66
Umbels/Plant	57.06	36.20	72.70	10.51	78.49
Umbellates/Umbel	10.66	7.67	12.80	1.16	83.24
Seeds/Umbellate	14.61	12.30	16.80	1.20	86.95
Seed yield/Plant (g)	47.20	7.96	91.32	17.88	51.68
Test Weight (g)	0.23	13.00	37.00	0.07	0.63

### Ajwain

Eighty four germplasm lines of ajwain were evaluated with three checks. The checks were AA-1, AA-2 and GA-1. Maximum variability was found in seed yield followed by test weight and number of secondary branch per plant while minimum was in days to 75% maturity (Table 5.6).



### 5.1.2 Cytogenetical and biochemical characterization of cumin

To study cytogenetical differences among cumin varieties GC-4 (bushy type) and RZ-209 (erect type) protocol was standardised for performing mitotic studies. The treatment of ice cold water for 2 hrs 30 minutes was found effective as pre-fixation for getting metaphase arrests in the root tips (1-2 cm length). The mitotic index observed was high in the above mentioned treatment compared to that of 2 hrs and 1 hrs 30 minutes duration. The fixation period was kept 24 hrs in 1:3 Farmers Solution (Alcohol: Acetic Acid Glacial), and preserved in 70 % ethanol. Root tips were hydrolysed in 1N HCl for 15 min at 60° C and then squash preparation were made in 2 % Acetocarmine stain.

## 5.2 Breeding for improvement in major seed spices

### 5.2.1 Breeding for high yield, quality and resistance to biotic and abiotic stress in fenugreek

Two entries of fenugreek namely AFg-3 and AFg-4 were evaluated in coordinated trial conducted during 2009-10, 2010-11 and 2011-12 at 12 locations around the country at Guntur, Dholi, Udaipur, Jabalpur, Faizabad, Hisar, Ajmer, Jobner, Coimbatore, Jagudan, Pantnagar and Raigarh. Both the entries *i.e.*, AFg-3 and AFg-4 stood at second and third

position with 7.26 and 7.58 per cent higher seed yield than the national check Hisar Sonali, respectively.

From the above coordinated trial AFg-3 has been identified as a variety for national release during XXIII AICRP on spices annual workshop held at IISR, Calicut. AFg-3 had 11.13 % higher seed yield (1288 kg/ha) than Hisar Sonali (National check) in coordinated testing at 12 locations across the country over three years. Seed yield of AFg-3 at Udaipur was 2595 kg/ha during 2011-12. The genotype is most stable and desirable for yield as per Eberhart and Russel Stability Model. It is moderately resistant to powdery mildew and root rot diseases. Seeds of AFg-3 contain 1.79 % diosgenin which is higher than national check and free amino acid 4-hydroxyisulucine content in the seeds is also higher than other varieties.

Ten advanced lines were evaluated in randomized block design with three check varieties namely AFg-1, AFg-2 and Hisar Sonali in three replications. Performance of these lines for different traits is presented in Table 5.8 A3-43-3 was the highest seed yielder with 23.28 q/ha followed by A3-47-1 (22.75 q/ha) as compared to best check AFg-2 having 19.36 q/h seed yield (Table 5.8 & Fig 1).

Table 5.8 Performance of fenugreek genotypes in trial

Name of Entry	Days to 50% flowering	Plant height (cm)	Pri. Branc. /Plant	Sec. Branc.s /Plant	Pods /Plant	Pod Length (cm)	Seeds /Pod	Test weight (g)
B2-19	45.0	65.53	4.13	5.03	45.6	11.6	14.4	14.4
A2-17-7	49.3	72.53	4.47	4.4	53.67	10.6	12.64	14.72
A1-1-2	49.3	67.07	4.33	4.8	55.67	9.9	14.27	12.69
A3-23-3	45.0	61.93	4.47	5.13	53.93	12.27	17.15	14.93
A3-28-9	48.3	65.63	4.13	4.4	48.0	9.6	14.56	14.22
A3-47-1	48.3	66.6	3.67	5.07	63.67	10.9	15.68	14.06
A3-43-3	45.0	64.93	4.07	4.8	52.0	11.27	17.69	14.94
B5-74-1	49.3	63.6	4.2	4.87	51.27	10.4	15.36	12.65
B5-73-1	49.7	63.53	3.8	5.47	49.13	11.13	15.68	12.79
A4-54-1	48.7	65.47	3.87	4.87	60.13	9.5	15.33	14.17
AFg-1	48.0	63.13	3.9	5.6	65.6	10.47	15.59	14.44
AFg-2	45.0	64.73	4.23	5.87	48.93	10.53	12.63	13.00
H.Sonali	49.0	57.33	3.49	5.47	50.4	11.13	15.79	12.78
Mean	47.7	64.77	4.06	5.06	53.69	10.72	15.14	13.83
CD(5%)	0.877	10.07	0.720	1.134	19.55	1.321	1.799	1.251
CV(%)	1.09	9.22	10.53	13.30	21.60	7.31	7.05	5.36



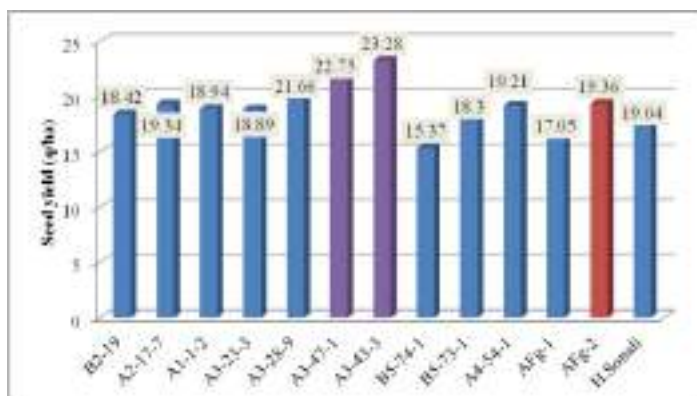


Fig 1 Performance of fenugreek genotypes for seed yield (q/ha) in trial

### Creation of variability in fenugreek through mutation breeding

In mutation breeding, 160 lines of  $M_5$  and  $M_6$  were sown in single row of 2 metre length in Augmented Block Design with respective parents used for mutation as checks. These 160 lines were previously selected as variants/mutants for plant type, plant height, leaf shape & size and growth behaviour. Observation on yield and contributing characters were recorded. The response of mutants for powdery mildew and *Alternaria* blight incidence were also recorded as given in table 5.9 and 5.10, respectively.

Table 5.9 Extent of variability observed in mutants lines in  $M_5$  &  $M_6$  generation for powdery mildew incidence

Parent	No of mutant lines	Powdery mildew (% PDI)		
		Min	Max	CV (%)
RMt-1	45	6.0	50.0	43.20
RMt-305	55	8.0	62.0	43.68
UM-344	43	18.0	50.0	25.51

Table 5.10 Extent of variability observed in mutant lines in  $M_5$  &  $M_6$  generation for blight incidence

Parent	No of mutant lines	Blight (% PDI)		
		Min	Max	CV (%)
RMt-1	45	14.0	58.0	33.5
RMt-305	55	10.0	82.0	43.99
UM-344	43	8.0	100.0	41.01

### Evaluation of fenugreek genotypes in limited water environments

Thirteen promising genotypes of fenugreek have been evaluated in three environments namely non-stress, mid-term stress and terminal stress. The experiment was laid with three replications in randomized block design. There were significant differences among entries in all the environments. The  $G \times E$  interaction was also significant for all the characters. The Joint Regression Analysis was carried out as suggested by Eberhart and Russell (1961). The stability parameters mean,  $\hat{\alpha}_i$  and  $s^2d$  were also calculated for all the genotypes for seed yield per plant (Table 10). It was found that genotype C-1-32-17 is relatively stable, however, genotypes AFG-3, AFG-6 and AM-413 have below average stability, therefore more suitable for better environment and AFG-4, B-2-19 and AM-293 had above average stability hence, more suitable for poor environment.

Table 5.11 Stability parameters mean,  $\hat{\alpha}_i$  and  $s^2d$  of the fenugreek genotypes for Seed yield / plant

Genotypes	Mean	$\hat{\alpha}_i$	$S^2d_i$
A-1-1-2	7.0411	1.57	4.9419**
AFg-6	9.3122	1.932	1.8982**
AFg-3	7.7033	1.673	1.8943**
RMt-305	7.0822	0.909	0.7648**
C-1-32-17	7.41	0.894	0.2692
Hisar Sonali	7.1089	1.567	2.8445**
AM-327	4.1522	0.262	2.280288
AM-292	4.7567	0.089*	-0.0918
AFg-4	7.5744	0.446	0.6072*
AM-413	8.8744	1.535	0.2689
B-2-19	8.5378	0.573	-0.0369
AM-293	8.9967	0.566	1.9186**
AFg-5	7.5378	0.983	2.6731**



### Effect of spacing and fertilizer level on new fenugreek genotype

An experiment was conducted in factorial randomized block design with three varieties (AFg-1, AFg-3 and AFg-4), two spacing (30x10 cm and 22x10 cm) and 2 fertilizer doses i.e. 100% recommended dose of fertilizer (RDF) (N:P:K::44:40:20) and 125% RDF (N:P:K::50:50:25). Interaction effect of spacing and fertilizer level on fenugreek genotype AFg 3 revealed that spacing of 22 cm with 125% recommended dose of fertilizers gave highest seed yield of 2699.44 kg/ha.

### 5.2.2 Breeding for high yield and quality in coriander

#### Evaluation of coriander populations

Twenty two coriander populations were evaluated with 4 check varieties namely ACr-1, RCr-435, Hisar Sugandh and RCr-41. The experiment was taken in randomized block design with three replications. Performance of coriander populations for seed yield is presented in figure 2. Entry SKCV-09-40 gave highest seed yield i.e., 16.41 q/ha followed by IC-570325 (16.16q/ha) and ACr 139 (15.85 q/ha).



Fig 2 Performance of coriander populations for seed yield

#### Gene pool maintenance

Three gene pools created earlier by pooling plants which were Early maturing and high yielding, small seed sized, having 4 basal leaf, medium height, higher no. of seed per umbel and higher yield, was maintained and advanced by carried out selections in the pools.

### 5.2.3 Enhancing genetic variability in cumin

Fifteen genotypes of cumin including two checks GC-4 and RZ-209 were evaluated at Ajmer and Jaisalmer. At Ajmer, genotypes CE-13, CE-15, CE-7, CE-8 and GC-4 were found promising, whereas at Jaisalmer (CAZRI, Regional Research Station), CE-5, CE-1, CE-15 and GC-4 showed good performance compared to other genotypes (Fig 3). Besides, 187 single plants were selected based on phenotypic performance and 150 lines were advanced which were selected from the wilt sick plot in the year 2011-12. To generate variability, 15 superior entries were independently bulked along with RZ-209 and were allowed to hybridize naturally. The population is advanced by selecting individual plant from each population.

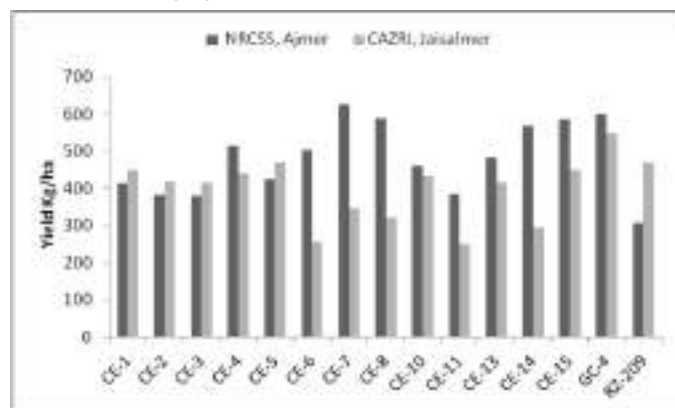


Fig 3 Yield performance of cumin genotypes at Ajmer and Jaisalmer

### 5.2.4 Breeding for high yield, quality and resistant to biotic and abiotic stress in fennel

#### Initial Evaluation Trial of Fennel

Nineteen selected populations were evaluated in initial trial at NRCSS. The analysis of variance revealed significant difference among the genotypes for all the traits including seed yield. The seed yield was ranging from 16 to 31 q/ha whereas the yield of check varieties were 25.09 q/ha (AF-1), 18.76 q/ha (GF-2), 22.89 q/ha (RF-143), 18.57 q/ha (RF-101) and 27.88 q/ha (RF-125). Among the tested entries three populations namely AF-05-12-1 (31.31 q/hac), AJ-FNL-2 (30.23 q/ha) and AF-05-7-1 (29.17 q/ha) were found superior over check varieties. Essential oil content in the populations was ranging from 0.29 to 2.86%. Maximum essential oil was observed in genotype AF-05-12-1 (2.86 %) whereas, as the best check RF-125 contained 2.54 % essential oil.



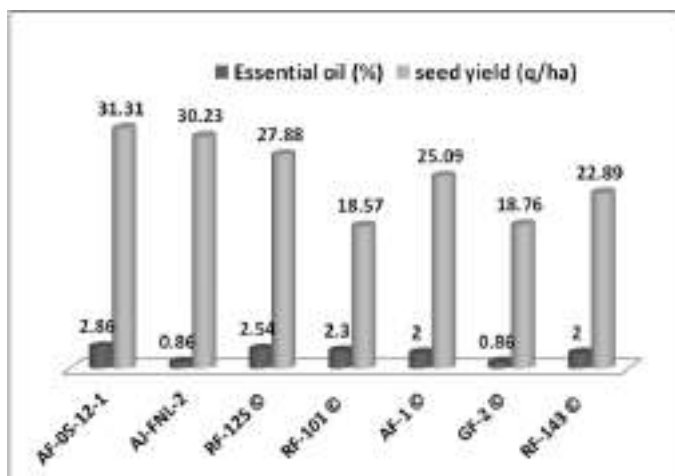


Fig 4 Essential oil and seed yield in elite populations of fennel

### Extra dwarf fennel genotype identified

One extra dwarf fennel plant was identified showing height only 35 cm, whereas the variety AF-1 has an height of 175 cm. This plant was maintained through selfing and seeds were harvested and preserved for further testing. The genotype will be used in hybridization programme for developing dwarf fennel varieties.



Dwarf plant of fennel

### Screening against *Ramularia* blight in fennel

Fourteen fennel varieties sown under IET were screened for *Ramularia* blight in which two varieties were found elite and described resistant namely FNL-50 (PDI 12.7) and AF-05 (PDI 14.7). Under germplasm evaluation only one fennel genotype AF-87 (PDI-14.7) was found resistant against *Ramularia* blight whereas three genotypes AF-05-2 (PDI 18.7), AF-05-1-3 (PDI 20.0) and AJ-FNL-2 (PDI 24.0) were

found moderately resistant. Genotype GF-2 (PDI 78.0) was reported highly susceptible followed by RF-101 (PDI 65.3).

## 5.3 Breeding for improvement in minor seed spices

### 5.3.1 Breeding for high yield and quality in dill

A trial was conducted with 12 test entries and two check varieties namely AD-1 and AD-2. The best check variety was AD-2 which gave 18.36 q/ha seed yield but it was at par with AD-1. The test entries AD-03-35 gave higher yield than check varieties (Fig 5). The population AD-67 matured early as compared to other populations.



Fig 5 Performance of dill genotypes in trial

### Creation of variability through gene pool approach

To create variability, a gene pool was developed on the basis of yield and umbel characteristics. This pool was advanced and maintained through close sib mating and planted in *rabi* 2010-11 for maximum introgression of genes within the gene pool.

### 5.3.2 Breeding for high yield, quality and resistant to biotic and abiotic stress in celery

#### Initial Evaluation Trial

Thirteen selected genotypes were evaluated in a randomized block design trial. The analysis of variance revealed significant differences among the genotype for all the traits including seed yield, which ranged from 1.51-3.05 q/ha and the check varieties namely A-Cel-1gave 2.97 q/ha seed yield. Among the thirteen genotypes one genotype A-Cel-08 (3.05 q/ha) was found elite for seed yield. Essential oil content was ranging from 0.20 to 1.88 %, the maximum (1.88 %) being observed in genotype A-Cel-7 followed by A-Cel-8 (1.80 %), whereas, check variety A-Cel-1 had only 1.62 % essential oil content.



Table 5.12 Variability recorded in celery during 2012-13

Plant Height	Test Weight	Seed Yield (q/ha)	Essential oil (%)	
A-Cel-1	54.27	1.36	2.97	1.62
A-Cel-2	72.33	0.33	1.78	0.20
A-Cel-4	72.00	0.81	1.94	0.24
A-Cel-5	72.33	0.41	2.68	0.30
A-Cel-6	61.33	0.18	2.21	1.60
A-Cel-7	61.67	0.62	2.33	1.88
A-Cel-9	61.00	0.56	1.72	1.00
A-Cel-8	58.93	0.51	1.51	1.00
A-Cel-11	66.73	0.75	1.91	1.80
A-Cel-1(S)	62.33	0.44	2.07	1.40
A-Cel-8(S)	77.60	0.44	3.05	1.50
A-Cel-10(S)	76.20	0.41	1.60	0.20
A-Cel-08	66.33	0.58	1.88	1.00
Early Celery	69.40	0.65	2.41	1.00
Mean	66.60	0.57	2.15	1.05
SD	6.95	0.28	0.49	0.61
CV	10.44	48.68	22.66	58.15

### 5.3.3 Breeding for high yield and improved quality in ajwain for rabi and kharif season.

A trial was conducted with 11 test entries and three check varieties namely Ajmer Ajwain-2, Gujarat Ajwain-1 and Lam Sel-2 during 2012-13. The check variety AA-2 gave 1472.60 kg/ha seed yield and it was at par with another check variety GA-1. The test entries AA-73(1701.04 kg/ha) and AA-27 gave higher yield (1655.83 kg/ha) than check varieties. AA-93 an early genotype which flowers in 46 days and mature in 115.8 DAS only maturity reported earlier was confirmed for the trait's heritability (earliness) and was advanced and maintained.



Ajwain genotype AA-93

### 5.3.5 Breeding for high yield and improved quality in Nigella

A trial was conducted on 10 advance line of nigella with 3 check varieties namely Ajmer Nigella-1, Pant Krishna and Azad Kalongi. Plant height, number of branches, days to 50 % flowering, yield attributing traits and seed yield kg/ha was recorded. The maximum seed yield (1003.55 kg/ha) was recorded in AN-21 and data are presented in Fig 6

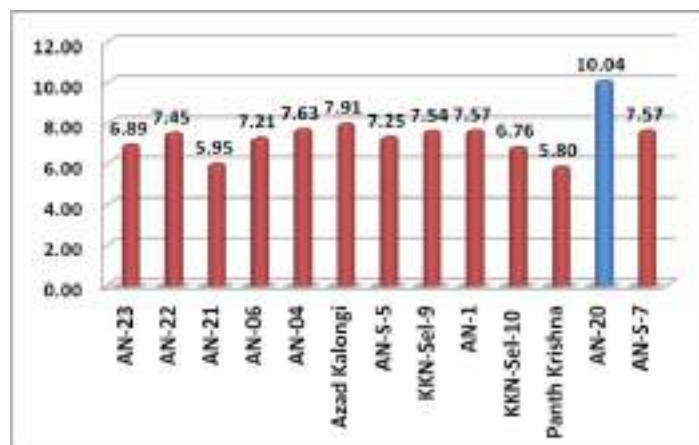


Fig 6 Performance of nigella genotypes for seed yield (q/ ha)

### 5.4 Deciphering molecular diversity and molecular characterization in seed spices

#### 5.4.1 Genetic diversity analysis through biotechnological tools in fenugreek

RAPD (Random Amplified Polymorphic DNA) analysis was done to study the genetic relationship in seventeen released varieties and 200 germplasm lines of fenugreek. Out of twenty primers tested, 15 amplified a total of 4289 RAPD bands, of which 689 were polymorphic showing 16% polymorphism, thus revealing a low degree of polymorphism whereas it was high (57.66%) among the released varieties indicated that there may be duplicity in collected germplasm. Cluster analysis of 1 - 0 bivariate data using UPGMA method delineated the genotypes into five groups and the data was further used for constructing a dendrogram. Genetic similarity matrix was calculated on the basis of Jaccards algorithm for RAPD data. (Fig 7)



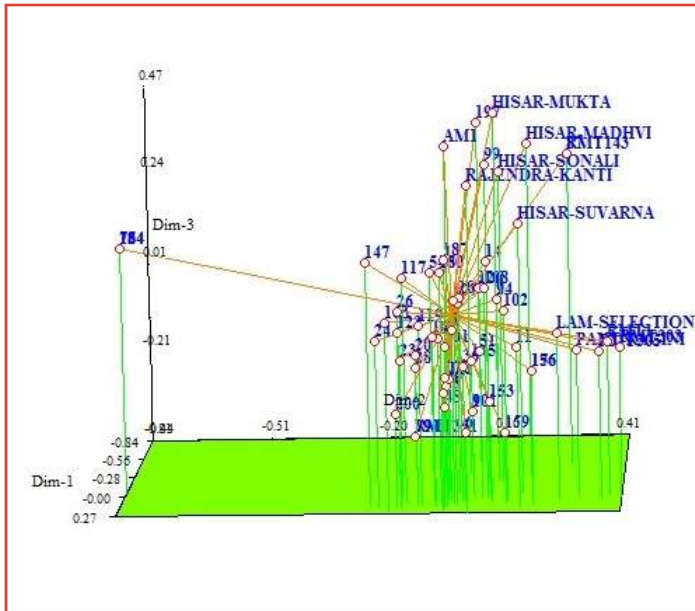


Figure 7 3-D graphs based on PCA analysis of fenugreek accessions of RAPD data

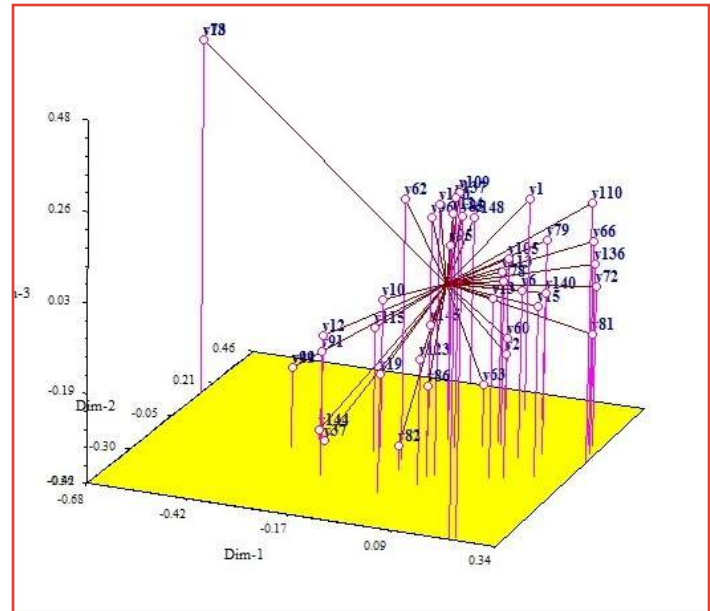


Fig 8 3-D PCA analysis of Cumin accessions based on RAPD data

#### 5.4.2 Molecular characterization of cumin

RAPD (Random Amplified Polymorphic DNA) analysis was performed to study the genetic relationship in 6 released varieties and 149 germplasm lines of cumin. Out of twenty primers tested, 15 amplified a total of 3269 RAPD bands, of which 518 were polymorphic showing 15.84% polymorphism, thus revealing a low degree of polymorphism whereas it was high (66.66%) among the released varieties which indicated that there may be duplicity in collected germplasm. Cluster analysis of 1 - 0 bivariate data using UPGMA method delineated the genotypes into four groups and the data was further used for constructing a dendrogram. Genetic similarity matrix was calculated on the basis of Jaccards algorithm for RAPD data. (Fig 8)

#### 5.4.3 Genomic study of fennel and coriander

RAPD (Random Amplified Polymorphic DNA) analysis was conducted to study the genetic relationship in 24 released varieties of coriander and fennel. Twenty primers of OPB series (Operon primers) were used in coriander generated a total of 622 RAPD bands out of which 268 were

polymorphic showing 43.08% polymorphism. Cluster analysis of 1 - 0 bivariate data using UPGMA method delineated the genotypes into two groups and the data was further used for constructing a dendrogram. Genetic similarity matrix was calculated on the basis of Jaccards algorithm for RAPD data. (Fig 9)

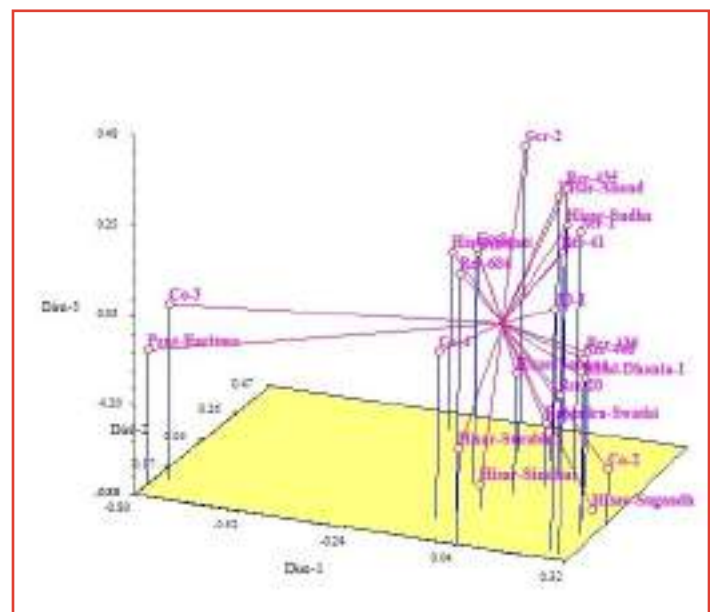


Fig 9 3-D PCA analysis of coriander accessions based on RAPD data



Fennel varieties and germplasm generated a total of 951 RAPD out of which 384 were polymorphic declaring 40.37% polymorphism. Cluster analysis of 1 - 0 bivariate data using UPGMA method delineated the genotypes into two groups and the data was further used for constructing a dendrogram. Genetic similarity matrix was calculated on the basis of Jaccards algorithm for RAPD data. (Fig 10)

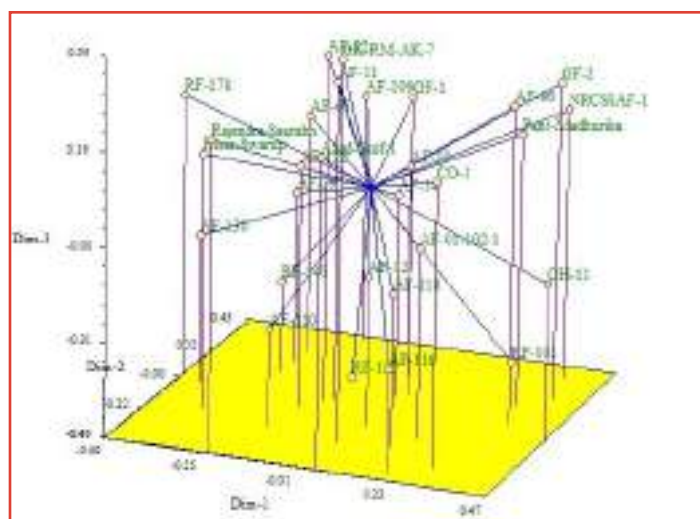
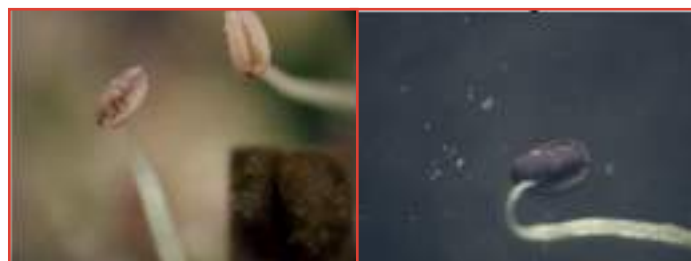


Fig 10 3-D PCA analysis of fennel accessions

## 5.5 Basic and applied studies on artificial hybridization in major seed spices

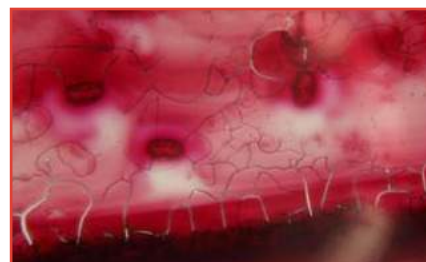
### 5.5.1 Standardization of technology for crossing in coriander (*Coriandrum sativum* L.)

A field experiment was conducted on coriander variety ACr-1 to find out the effect of different chemical hybridizing agents (CHAs) on induction of pollen sterility. Twenty different treatment combinations were applied as spray at flower primordia initiation stage @ 25 ml per plant. Experiment was laid out in randomized block design with three replications. Anther dehiscence was found normal but the pollen sterility was recorded in two treatments of 2,4-D and MH upto 60%. These treatments did not affect the ovular sterility significantly (6.67% only). Significant difference was observed *w.r.t.* other ancillary data. No adverse effect on number of pollinator visit was recorded after application of this treatment. Peak visit time was 10-11 AM followed by 4-5 PM. At higher concentration of 2,4-D and MH, both plant and floral abnormalities were observed.



Normal anther dehiscence in T8 and T17

2,4D (150 mg/l and MH at 200 mg/l and above



Normal pollen on stigmatic surface

## 5.6 Precision resource management in seed spices production

### 5.6.1 Scaling up water productivity in cumin and nigella

In cumin, irrigation through low pressure drip resulted in highest growth parameters and yield attributes viz. umbel/plant (9.68), umbellate/plant (39.08), test weight (4.68 gm), seed weight/plant (4.25 gm) and yield (607.52 kg/ha) and WUE (3.45 kg/ha-mm) followed by drip irrigation. Among the various water conservation techniques mulching with 20 micron plastic sheet exhibited highest yield attributes viz. umbel/plant (9.82), umbellate/plant (40.54), test weight (4.78 gm), seed weight/plant (4.18 gm) and yield (605.01 kg/ha) followed by drip irrigation.

In nigella, irrigation through high pressure drip resulted in highest yield attributes viz. branch/plant (9.21), capsules/plant (44.71), test weight (2.60 gm), seed weight/plant (6.99 gm) and yield (1745.29 kg/ha) and WUE (7.72kg/ha-mm) followed by surface irrigation. Among the various water conservation techniques mulching with 20 micron plastic sheet exhibited highest plant growth parameters and yield attributes e.g. branches/plant at maturity (8.66), capsules/plant (42.83), test weight (2.56), seed weight (6.43 gm/plant) and seed yield (1687.88 kg/ha).





Nigella 80 DAS



Nigella 110 DAS

### 5.6.2 Effect of land configuration and water management techniques on yield of seed spices in maize (baby corn) based cropping system

#### Cumin-maize (baby corn) cropping system

The yield of baby corn under surface, drip and micro sprinkler irrigations was 3230, 3376 and 2610 kg/ha respectively whereas with flat bed, raised beds of 75 and 150 cm width the yield of baby corn was 3315, 3465 and 2436 kg/ha. After harvest of the baby corn, cumin variety GC-4 was sown and five irrigations were given to the crop measuring 22.11, 7.12 and 9.43 ha cm water through surface, drip and micro sprinkler systems whereas, 13.57, 11.31 and 13.78 ha cm water was delivered under flat, raised beds (75 cm) and wider beds (150 cm). Drip irrigation not only enhanced the yield of cumin by 37.95 and 17.72 % than surface and micro sprinkler irrigation but also improved the water productivity and gave 73.58 kg seed/ha cm irrigation water. The improvement in water productivity with drip irrigation was 58.08 and 27.88 kg seed/ha cm irrigation water than the surface and sprinkler irrigation. Among land configuration treatments, sowing of 3 rows of cumin on raised beds (75 cm) enhanced the grain yield by 47.60 and 25.21 % and water productivity by 30.39 and 20.68 kg seed/ha cm irrigation water (Fig 11) than flat bed and wider raised beds (150 cm).



Maize for baby corn and produce of the baby corn at harvest

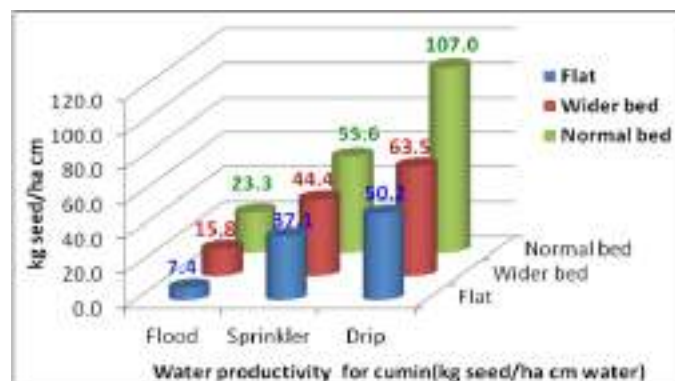


Fig 11 Effect of irrigation techniques and land configuration on water productivity (kg seed/ ha cm irrigation water) in cumin.

#### Kasuri methi -maize (baby corn) cropping system

Irrigation with micro sprinkler in kasuri methi not only enhanced the yield by 24.7 and 26.4 % but also improved the water productivity by 22.5 and 8.1 kg grain/ha cm irrigation water (Fig 12) than surface and drip irrigation methods. Among land configuration treatments, sowing of kasuri methi on flat bed enhanced the grain yield by 26.1 and 28.2 % and water productivity by 3.5 and 4.3 kg grain/ha cm irrigation water than raised beds (75 cm) and wider beds (150 cm), respectively. Kasuri methi crop performance was better when sown on flat beds with micro sprinkler irrigation method.

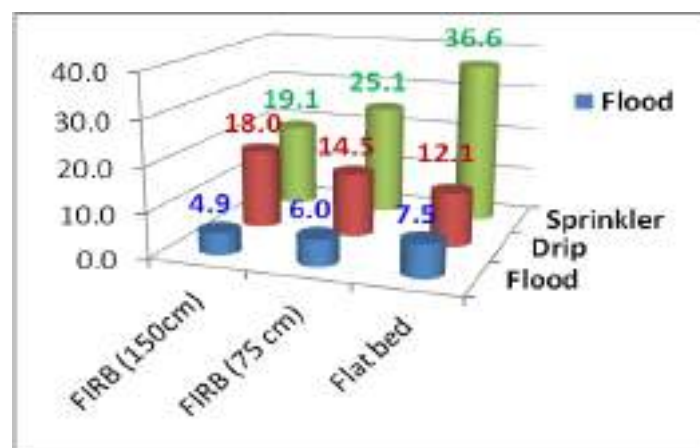


Fig 12 Effect of irrigation techniques and land configuration on water productivity (kg seed/ ha cm irrigation water) in kasuri methi



### 5.6.3 Standardization of NPK levels for coriander and cumin under protected environment in the scenario of climate change

In coriander, maximum plant height at harvest, maximum number of umbels per plant, number of seeds per umbellate and highest yield (1841.11 kg/ha) were obtained under plastic walk in tunnel with 100 % RDF closely followed by 80 % RDF with the yield of 1831.94 kg/ha. Based on the results, it is inferred that plastic walk in tunnel with 80 % RDF in coriander is better for realizing higher growth, yield attributes, yield and net returns of Rs. 2,15,807/ha over control. Aphid incidence was also minimum (19.66/umbel) under the same treatments as compared to control/open conditions (28.11/umbel).

**Table 5.12** Interaction effect of protected environment and nutrient levels on yield of coriander

Environment	Yield (kg/ha) 2012-13			
	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>
Plastic walk in tunnel	835.56	946.94	1831.94	1841.11
Green Net walk in tunnels	785.00	918.06	1501.11	1656.67
Open conditions	717.50	810.83	893.61	934.72
SEm±		49.07		
CD (P=0.05)		145.76		
CV %		7.46		

Here:

N<sub>1</sub>= 40% RDF (N: P: K., 24:12:04 kg/ha), N<sub>2</sub>= 60% RDF (N: P: K., 36:18:06 kg/ha) N<sub>3</sub>= 80% RDF (N: P: K., 48:24:08 kg/ha), N<sub>4</sub>= 100% RDF (N: P: K., 60:30:10 kg/ha)

In case of cumin insect proof net tunnel with 80% RDF treatment exhibited better growth and development, i.e. maximum plant height at harvest, maximum number of umbels per plant, number of seeds per umbellate and highest yield (736.25 kg/ha). The minimum incidence of aphids (7.89/umbel) was recorded under the same treatment as compared to control/ open conditions (28.26/umbel). Cumin produced under insect proof net walk in tunnels with 80% RDF exhibited higher returns Rs. 61,025/ha over control.

**Table 5.13** Interaction effect of protected environment and

Environment	Yield (kg/ha) 2012-13			
	N <sub>1</sub>	N <sub>2</sub>	N <sub>3</sub>	N <sub>4</sub>
Insect proof net (20% Mesh)	373.29	563.17	736.25	732.81
Black net (50%)	402.14	424.10	498.58	565.75
Open conditions	407.26	430.13	430.13	475.08
SEm±		24.05		
CD (P=0.05)		71.45		
CV %		8.28		

Here:

N<sub>1</sub>= 40% RDF (N: P: K., 12:08:08 kg/ha), N<sub>2</sub>= 60% RDF (N: P: K., 18:12:12 kg/ha) N<sub>3</sub>= 80% RDF (N: P: K., 24:16:16 kg/ha), N<sub>4</sub>= 100% RDF (N: P: K., 30:20:20 kg/ha)



Performance of coriander and cumin under protected structures

### 5.6.4 Fertilization scheduling for efficient nutrient and water management in major and minor seed spices

#### Standardization of irrigation and planting/ sowing techniques for seed spices

The main plot treatments comprising of 6 seed spice crops i.e. coriander, fenugreek, fennel, ajwain, dill, celery and 5 sub plot treatments of land configurations i.e. raised bed of 75 cm with 1 and 2 row and 150 cm raised beds with 2, 3 and 4 rows of the crop coupled with drip fertigation. One to four number of crop rows were accommodated on raised bed (FIRB) having 35 and 90 cm upper width, respectively whereas spacing between two furrows were 75 and 150 cm in normal and wider beds, respectively. The results showed that raised beds of 75 cm with paired row planting coupled with one drip line for fertigation gave maximum yield of 2000.0, 2133.3, 2083.3, 1639.8 and 1740.8 kg/ha in coriander, fenugreek, fennel, ajwain and dill (Table 5.14), whereas in celery single row coupled with one drip line on 75 cm raised bed gave maximum yield (934.0 kg/ha)



Table 5.14 Effect of raised beds size and number of rows on seed yield (kg/ha) of seed spices planted under drip fertigation

Treatment	Raised bed (75 and 150 cm) with number of crop rows					Mean A
	75 cm 1 row	75 cm 2 row	150 cm 2 row	150 cm 3 row	150 cm 4 row	
Coriander	1,466.5	2,000.0	700.3	583.3	600.0	1,070.0
Fenugreek	1,533.3	2,133.3	733.5	483.3	566.5	1,090.0
Fennel	1,356.8	2,083.3	724.3	582.0	613.8	1,072.0
Ajwain	1,396.5	1,639.8	467.0	397.8	420.0	864.2
Dill	1,510.3	1,740.8	1,028.8	811.8	598.5	1,138.0
Celery	934.0	753.8	219.3	207.0	238.0	470.4
<b>Mean B</b>	<b>1,366.2</b>	<b>1,725.1</b>	<b>645.5</b>	<b>510.8</b>	<b>506.1</b>	
Factors	±SEm		CD at 5%			
Factor(A)	82.9		252.3			
Factor(B)	61.5		173.8			

### Effect of different irrigation techniques on growth and yield of major and minor seed spices

An experiment was conducted to find out the effect of different irrigation techniques on growth and yield of major and minor seed spices. The main plot treatments comprising of 2 irrigation methods i.e. Gyro net (micro sprinkler) and mega net (mini sprinkler) and 9 seed spice crops i.e. Coriander, fenugreek, cumin, fennel, ajwain, dill, celery, nigella and anise as sub plot treatments. The results showed that mega-net was performed better and gave 38.6, 26.5, 52.8, 11.0, 13.4 and 15.9 % higher seed yield in fenugreek, cumin, fennel, ajwain, niagella and anise than the gyro net (micro sprinklers), respectively. Whereas gyro net (micro sprinkler) was found better and gave 14.3, 19.6 and 9.6 % higher yield in coriander, dill and celery than the mega net sprinkler.

### Standardization of nursery raising techniques and transplanting seedlings of vegetables and seed spices

Different combinations of coco peat, vermiculite and perlite was used as nursery raising media and the ratio of 2.5:1:1 (v/v) was found best for raising the seedlings of vegetables (tomato, chilli, capsicum, Khira etc) and seed spices (fennel, celery, ajwain and dill). The vegetable

seedlings were transplanted in the insect proof net house and produce was sold in the local market/ staff of the NRCSS. The nursery of vegetables was also sold to nearby 8-10 farmers who are having the protected cultivation facilities.

### 5.7 Cropping system and weed management in seed spices

#### 5.7.1 Evaluation and identification of efficient cropping sequences for seed spice growing area

A field experiment comprising of fourteen cropping sequences viz. Green gram-Fennel-Summer fallow, Green gram-Fennel-Green manuring, Black gram-Fennel-Summer fallow, Black gram-Fennel-Green manuring, Cowpea-Fennel-Summer fallow, Cowpea-Fennel-Green manuring, Groundnut-Fenugreek- Summer fallow, Groundnut-Fenugreek- Green manuring, Cluster bean-Cumin-SF with SS, Cluster bean-Cumin- SF without SS, Cluster bean-Cumin- GM, Green manuring- Cumin- SS, Pearl millet - Cumin- SF without SS and Pearl millet - Cumin- SF with SS was conducted during 2010-2013 with three replications in simple randomized block design. Based on data of three years, it has been confirmed that Green gram- Fennel-



Gyro net (micro sprinkler) and mega net (mini sprinkler) in different seed spices



Green manuring cropping followed by Green gram- Fennel-Summer fallow is better in fennel based cropping sequence and Cluster bean- Cumin Summer solarisation followed by Cluster bean- Cumin- Green manuring is better among cumin based cropping sequence for realising higher fennel equivalent yield, net return and BCR. Further it has been revealed that Pearl millet-Cumin-Summer solarisation exhibited lowest wilt incidence in cumin followed by in Cluster bean-Cumin summer solarisation cropping sequence.

with *Azotobactor* and PSB. Thus, application of 75 percent N&P through vermicompost, enriched vermicompost +seed inoculation with *Azotobactor* and PSB is better for realizing higher yield of coriander and cumin. In management of disease in cumin and coriander it was found that highest yield of coriander (832 kg /ha) and cumin (280 kg /ha) was recorded with the application of Seed treatment + Soil application of *Trichoderma viridie* + soil application of neem cake @ 150 kg ha + foliar spray of Karanj oil followed by seed

Table 5.15 Effect of cropping sequences on fennel equivalent yield, net return and BCR

S. No	Treatments	FEY (kg /ha)	TCC (Rs/ha)	NR (Rs/ha.)	BCR
1	Green gram-Fennel- SF	2712	35382	121918	3.45
2	Green gram-Fennel-GM	2928	39982	129848	3.25
3	Black gram-Fennel-SF	2310	34682	99304	2.86
4	Black gram-Fennel- GM	2340	39282	96444	2.46
5	Cowpea-Fennel-SF	2340	33798	101898	3.01
6	Cowpea-Fennel-GM	2473	38398	105034	2.74
7	Groundnut-Fenugreek- SF	2435	44273	96972	2.19
8	Groundnut-Fenugreek- GM	2575	47273	105094	2.23
9	Cluster bean-Cumin-SS	4645	33042	236368	7.15
10	Cluster bean- Cumin- SF	4265	31109	216242	6.95
11	Cluster bean- Cumin- GM	4795	35709	242401	6.79
12	Green manuring- Cumin- SS	1079	26425	36137	1.37
13	Pearl millet - Cumin- SF	1727	28750	71420	2.48
14	Pearl millet - Cumin- SS	2010	30684	85900	2.80
	CD (P=0.05)	201	-	6930	0.44

SF=Summer Fallow, GM=Green Manure, SS=Summer Solarisation, FEY=Fennel Equivalent Yield, TCC=Total Cost of Cultivation, NR=Net Return, BCR=Benefit Cost Ratio

### 5.7.2 Standardization of package for organic seed spice production (coriander and cumin)

Experiments on coriander and cumin for management of nutrition, insect pest and disease management were conducted during 2010-11 and 2011-12 and the best treatment was tried in large scale demonstration. Based on two years study it was found that application of 100 per cent N & P through vermicompost and enriched vermicompost resulted the highest yield of coriander (588 kg/ha) and cumin (337 kg/ha) being at par with the application of 100 per cent N and P through sheep manure and enriched vermicompost and 75 per cent N &P through vermicompost, enriched vermicompost +seed inoculation

treatment + soil application of *Trichoderma viridie* + soil application of neem cake @ 150 kg ha + foliar spray of sulphur compounds (Table 5.16).

Spray of sulphur compound of karanj extract 1% followed by application of Allylisoithio cynate 1% is effective for control of insect pest in coriander and cumin. In large plot demonstration during 2012-13 it has been confirmed that integrated treatment for nutrient, insect pest and disease management in coriander resulted better growth and higher yield was obtained in comparison to control. In cumin integrated management of nutrient, insect pest and disease exhibited better performance over control in respect to growth parameters but yield could not be obtained due to sudden attack of blight.



Table 5.16 Effect of organic source of nutrition on yield of coriander and cumin

Treatments	Seed yield (kg/ha)	
	Coriander	Cumin
100% N & P through VC & En. VC	588	338
100% N & P through SM & En. VC	579	322
100% N & P through PM & En. VC	573	317
75% N & P through VC & En.VC +Azot.	547	296
75% N & P through SM & En.VC + Azot.	512	270
75% N & P through PM & En.VC +Azot.	509	271
75% N & P through VC & En.VC + Azot+ PSB	567	311
75% N & P through SM & En. VC + Azot+PSB	558	307
75% N & P through PM & En. VC+ Azo+PSB	522	305
Absolute control	468	263
CD (P=0.05)	58	32

VC= Vermi-compost, PM=Poultry manure, En VC= Enriched vermi-compost, SM=Sheep manure  
PSB=Phosphate solublizing bacteria

### 5.7.3 Standardization of sustainable and profitable cropping system with fruit crops

The study was conducted with six seed spice crops in association with fruit trees and in open space. The highest seed, stover and biological yield of seed spices was obtained in open space followed by Aonla association. The fruit yield of Ber and Aonla were also recorded. All the yields were converted into coriander equivalent yield (kg/ ha) for proper interpretation of the result. All the seed spices resulted higher coriander equivalent yield with Ber in comparison to Aonla and open space. Among seed spices fenugreek association with fruit trees proved highly beneficial which resulted higher coriander equivalent yield with Ber as well as Aonla



Ber and aonla orchard in kharif season



Ber and fenugreek orchard in rabi season

### 5.7.4 Identification of critical stage for weed management in seed spices (coriander, ajwain and fennel)

Three field experiments involving coriander, fennel and ajwain were conducted during 2012-13. There were 18 treatments comprising of initial weed free periods of 15, 30, 45, 60, 75, 90, 105, 120 days after sowing (DAS) and weedy upto 15, 30, 45, 60, 75, 90, 105, 120 DAS along with weed free till harvest (weed free check) and weedy till harvest (un-weeded check) in coriander and ajwain. Whereas, 22 treatments comprising of initial weed free periods of 15, 30, 45, 60, 75, 90, 105, 120, 135, 150 days after sowing (DAS) and weedy upto 15, 30, 45, 60, 75, 90, 105, 120, 135, 150 DAS along with weed free till harvest (weed free check) and weedy till harvest (un-weeded check) were used in fennel. The treatments replicated three times in a randomized block design. Weed flora of the experimental field consisted of *Chenopodium murale* L., *Chenopodium album* L., *Cynodon dactylon* L. and *Cyperus rotundus*. Maximum seed yield of coriander, ajwain and fennel (1877.8, 2409.3 and 2809.3 kg/ha) were recorded with the weed free throughout growth period treatment, where as lowest were recorded at weedy check plots, respectively. On the basis of one season data, the critical stage for weed competition in coriander, ajwain and fennel were 56, 52 and 51 days respectively (Fig 13). The loss in yield due to weeds (weedy throughout growth) in coriander, ajwain and fennel were 1597.7, 2185.2 and 2713.0 kg/ha as compared with weed free plots. The loss in yield due to weeds (weedy upto 15 DAS to weedy throughout growth period) were range from



20.9-85.1 % in coriander to 9.9-90.7 % in ajwain and 1.9-96.6 % in fennel as compared with weed free plots. There are negative returns due to very less yield of coriander, ajwain and fennel in weedy throughout growth period plots.

Table 5.17 Seed yield of coriander, ajwain and fennel under different treatments of weedy and weed free period DAS.

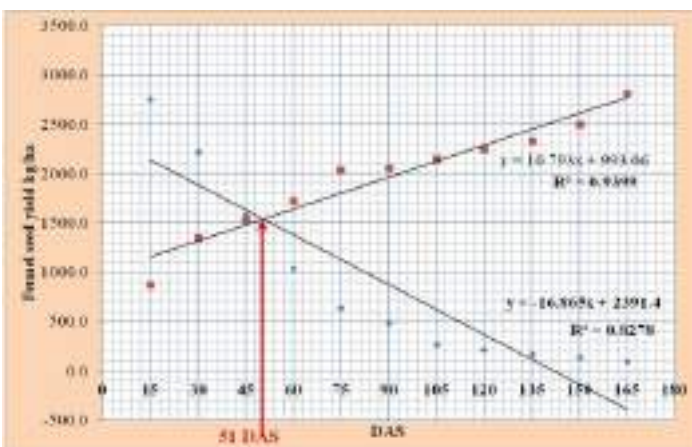
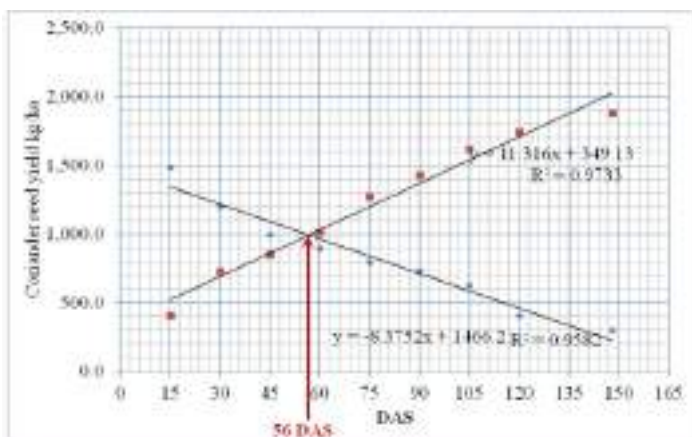


Fig 13. Critical stage (days after sowing) for weed competition in coriander, ajwain and fennel

Treatments	Seed yield (kg/ha)		
	Coriander	Ajwain	Fennel
Weedy up to 15 DAS	1,485.2	2,16.5	2,755.5
Weedy up to 30 DAS	1,198.1	1,84.4	2,179.6
Weedy up to 45 DAS	996.3	1,60.0	1,585.2
Weedy up to 60 DAS	896.3	1,26.4	1,037.0
Weedy up to 75 DAS	796.3	1,08.5	637.0
Weedy up to 90 DAS	733.3	848.2	487.1
Weedy up to 105 DAS	625.9	757.4	264.8
Weedy up to 120 DAS	403.7	392.6	218.5
Weedy up to 135 DAS	-	-	174.1
Weedy up to 150 DAS	-	-	140.7
Weedy throughout	298.1	224.1	96.3
Weed free up to 15 DAS	403.7	544.4	875.9
Weed free up to 30 DAS	725.9	1,15.0	1,348.2
Weed free up to 45 DAS	848.2	1,47.0	1,529.6
Weed free up to 60 DAS	1,011.1	1,93.4	1,727.8
Weed free up to 75 DAS	1,272.2	2,11.8	2,037.0
Weed free up to 90 DAS	1,429.6	2,13.2	2,059.3
Weed free up to 105 DAS	1,618.5	2,20.2	2,151.9
Weed free up to 120 DAS	1,740.8	2,36.4	2,242.6
Weed free up to 135 DAS	-	-	2,331.5
Weed free up to 150 DAS	-	-	2,496.3
Weed free throughout	1,877.8	2,40.3	2,809.3
CD at 5%	160.4	396.1	231.3

### 5.8 Post Harvest management and value addition in seed spices

#### 5.8.1 Development and standardization of harvest and post harvest processing and value addition through CAP/MAP of Seed Spices Crops

The harvesting indices for fennel were identified to be 181 DAS which gave maximum green fennel grain recovery of 42.97% with highest scores of other quality parameters. Drying techniques had shown solar dryer to be best for harvested crop, for best qualitative and quantitative recovery (39.82%) with highest test weight of 5.17 g in lowest possible time of 36 hrs. The experiments on storage behavior of fennel under ambient and controlled environmental condition for shelf life enhancement had shown significantly better results under aluminum vacuum packaging up to eight months after harvest with lowest seed



damage of 4.25%, lowest moisture content of 8.07 %, highest seed viability of 89.47% and highest essential oil content of 1.29% in fennel seeds, as compared to control (Jute bag) having highest seed damage (19.82%), highest moisture content (9.21%), lowest seed viability (57.40) and lowest essential oil content (1.09%). Suitable MAP on survival and feeding of cigarette beetle in fennel has been studied, which gave significantly good results with CO<sub>2</sub> alone, N<sub>2</sub> alone, O<sub>2</sub> alone, vacuum and various combinations over control conditions with all insects dead and shiny green to pale yellow colour of fennel after storage period as compared to 119 insect count with 52.66% damage and dull colour in control conditions. Best treatment (Aluminium vacuum packing) resulted in a net return of Rs. 5658.25 as compared to Rs 2488.1 under control conditions (Jute bag) after eight months of storage (Table 5.18).

Table 5.18 Economics of Aluminium vacuum packing of fennel under storage as compared to control (Average of 2 years)

S. No.	Treatment	% loss	Effective produce to sell	Input	Gross Return (Rs./q)	Net Return
1	Best treatment (Aluminium vacuum packaging)	4.25	95.75 * 75	1523	7181.25	5658.25
2	Control (Jute bag packaging)	19.82	80.18 * 45	1120	3608.10	2488.1

The harvesting indices for cumin were identified to be 115 DAS which gave maximum recovery of 37.20% with minimum moisture content (56.8%) and maximum scores of other quality parameters such as colour (9/10), taste (9/10), and test weight (3.84 g). Drying techniques had shown solar dryer to be best for harvested crop, which exhibited highest qualitative and quantitative recovery (29.82 %) with minimum moisture content (61.30%) and maximum test weight (3.87g) and scores of other quality parameters such as color (9.5/10) and taste (9.5/10). The experiments on storage behavior of cumin under ambient and controlled environmental conditions for shelf life enhancement had shown significantly better results for aluminium vacuum

packaging up to eight months after harvest with lowest seed damage (6.97 %), lowest moisture content (7.61%), highest seed viability (88.67%) and highest essential oil content (2.50 %) in cumin seeds, as compared to control (Jute bag) having highest seed damage (20.65%), highest moisture content (9.04%), lowest seed viability (63.90) and lowest essential oil (1.57%). Suitable MAP on survival and feeding of cigarette beetle in cumin has been studied, which gave significantly good results with CO<sub>2</sub> alone, N<sub>2</sub> alone, O<sub>2</sub> alone, vacuum and various combinations over control conditions with all insects dead and shiny grey to pale colour of cumin after storage period as compared to 115 insect count with 48% damage and dull colour in control conditions. Best treatment (Aluminium vacuum packing) has given a net return of Rs. 11501.2 as compared to Rs 5624.75 under control conditions (Jute bag) after eight months of storage (Table 5.19).

Table 5.19 Economics of aluminium vacuum packaging of cumin under storage as compared to control

S. No.	Treatment	% loss	Effective produce to sell	Input	Gross Return (Rs./q)	Net Return
1	Best treatment (Aluminium vacuum packaging)	6.97	93.03* 140	1523	13024.2	11,501.2
2	Control (Jute bag packaging)	20.65	79.35* 85	1120	6744.75	5,624.75

## 5.9 Microbiological approaches in integrated nutrient management in seed spices

### 5.9.1 Screening of plant growth promoting rhizobacteria for coriander (*Coriandrum sativum* L.)

All the previously isolated, thirty six coriander rhizospheric bacterial strains were screened for their ability to promote seedling germination and growth. There was significant increase in germination per cent of coriander seeds in all the treatments except, Cor-19 and Cor-25 and Cor-32 which were at par with control while Cor-18 resulted



in lesser than control. Treatment Cor-15 resulted into highest seed germination per cent (86.66%) which was at par with Cor-27 & Cor-8. Highest radical length of coriander seedling was observed with Cor-8 treated seeds followed by Cor-34 where as highest plumule length was observed with Cor-8 followed with Cor-27.

Rhizobacterial strains were selected for their plant growth promoting potentials based on per cent increase in seed vigour index over control. Seed vigour index of the treatments ranged from 4826.18 to 8365.38 and per cent increase over control ranged from 2.22 to 73.33 %. Treatment Cor-27 gave highest increase of seed vigour index over control followed by Cor-8 and Cor-15 (Fig.14).

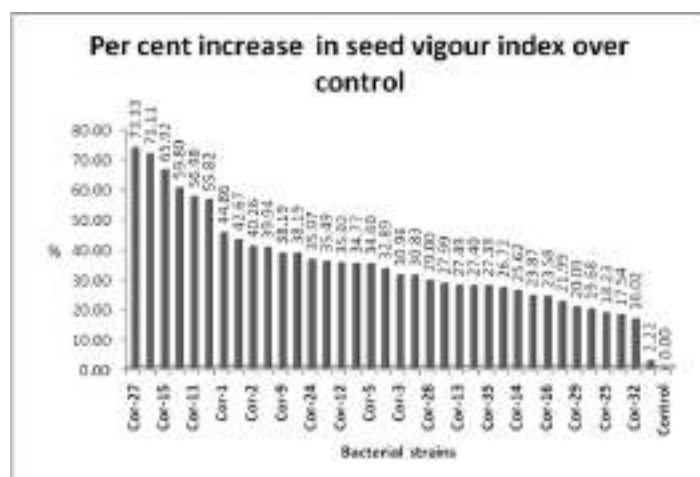


Fig 14 Per cent increase in seed vigour index of coriander seeds treated with bacterial isolates over control

The shoot and root lengths as well as shoot and root dry weight of treated coriander plants were found to be significantly higher over control treatment at 30 days after sowing. However, at maturity stage, there was non-significant effect of various rhizobacterial cultures treatment. The seed yield ranged from 0.45g to 0.93 g per plant and maximum was recorded with Cor-8 which was at par with Cor-4 treated coriander plants (Table 5.20).

Table 5.20 Effect of rhizobacterial cultures inoculation on coriander growth and yield in pot experiments

Culture No.	Length (cm)		Fresh wt (g)		Dry wt (g)		DAS to Maturity	Yield/ plant (g)
	Shoot	Root	Shoot	Root	Shoot	Root		
Cor-4	44.0	13.3	58.2	4.4	7.0	0.78	105	0.92
Cor-5	43.8	12.2	58.3	4.6	6.8	0.70	108	0.72
Cor-7	40.6	11.8	55.4	4.2	6.2	0.70	110	0.48
Cor-8	48.0	13.5	65.0	5.3	7.8	1.00	103	0.93
Cor-11	42.0	12.7	58.0	4.3	6.8	0.80	108	0.74
Cor-15	45.6	12.2	60.0	4.6	6.6	0.70	108	0.66
Cor-16	43.0	11.2	55.0	4.0	6.4	0.60	110	0.44
Cor-18	45.7	13.8	60.1	4.8	6.9	0.80	105	0.80
Cor-22	45.0	13.3	58.6	4.5	7.4	0.81	105	0.81
Cor-27	46.0	13.1	60.3	4.1	6.7	0.78	106	0.80
Control	40.0	11.3	53.0	3.8	5.9	0.50	112.0	0.45
CD (0.05)	NS	NS	1.86	NS	NS	NS	4.2	0.28

### 5.9.2 Isolation and evaluation of phosphate solubilising microorganisms for fennel (*Foeniculum vulgare* L.)

Fennel plant and soil samples have been collected from Ajmer, Pali Jhalawar, and Kota Districts of Rajasthan for isolation of rhizospheric bacteria. Total fourteen soil samples have been analysed for EC, pH, bacterial count and fungal count. Sixteen phosphate solubilizing microorganism were isolated on Pikovskaya medium and these were further screened on National Botanical Research Institutes Phosphate (NBRIP) medium. Quantitative assay of phosphate solubilisation was done in NBRIP broth. Maximum phosphate solubilization in broth assay was observed in bacterial isolates FEN-14 which was at par with FEN-1 and FEN-5. Based on diameter of radial growth of bacterial isolates and zone of clearance of modified NBRIP medium ager plates Phosphate Solubilization Index was calculated. All the PSB isolates were further screened for their pH tolerance and it was observed that majority of PSB cultures were able to grow in pH range of 5.0-8.0 and only few PSB isolates were able to grow at pH 9.0.

There was significant effect of PSB isolate cultures applied in Fennel pot having pre-sterilized soil and kept in open ambient conditions. Shoot length ranged from 15 to 27 cm at 30DAS and highest shoot length was recorded for Fen-5 treatment which was at par with Fen-3, Fen-6 and Fen-9. Similarly, root length varied from 3.0 to 4.8 cm at 30 DAS. The fresh weight of shoot and root ranged from 6.86 to 8.25 g and 0.9 to 1.5 g respectively. Dry weight of shoot and



root ranged from 0.59 to 1.27 g and 0.34 to 0.42 g respectively at 30 DAS of fennel seedlings (Table 5.21).

Table 5.21 Effect of PSB cultures on fennel plant growth at 30 DAS in pot experiment

Treatment	Length (cm)		Fresh wt. (g)		Dry wt. (g)	
	Shoot	Root	Shoot	Root	Shoot	Root
FEN-1	19.0	4.0	7.21	1.1	0.86	0.35
FEN-2	20.0	4.2	7.54	1.2	0.94	0.38
FEN-3	24.0	4.8	7.96	1.3	1.02	0.40
FEN-5	27.0	5.5	8.25	1.5	1.27	0.42
FEN-6	24.0	4.6	7.88	1.3	1.05	0.40
FEN-7	20.0	4.1	7.43	1.2	0.93	0.37
FEN-8	18.0	3.8	7.12	0.9	0.74	0.34
FEN-9	24.0	4.8	8.00	1.3	1.03	0.39
Control	15.0	3.0	6.86	1.0	0.59	0.34
CD(0.05)	3.86	1.1	0.60	0.13	0.22	NS

## 5.10 Assessment of edaphic stresses and nutrient management for sustainable seed spices production

### 5.10.1 Nutrient management for sustainable seed spices production

#### Threshold level of N requirement of coriander (ACr-1)

Results revealed that yield attributes and nutrient uptake increased with higher doses of N, whereas harvest index was highest with 60 kg nitrogen. Number of leaf, petiole length, chlorophyll content, total root length, root area, number of root tips and average root diameter were also enhanced with N inputs (Fig 15, 16) However, tap root length and leaf angle decreased with increase in nitrogen.

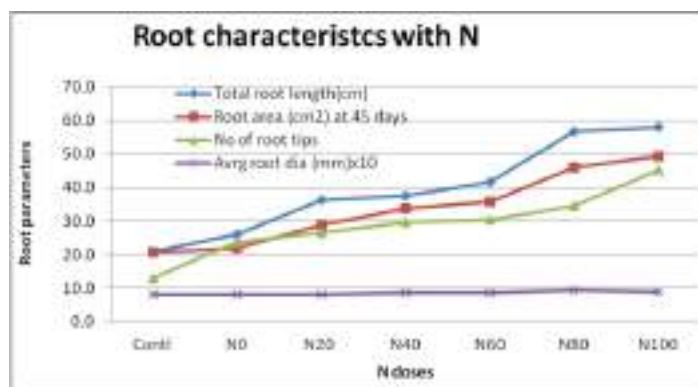


Fig 15 Effect of N levels on root characteristic of coriander

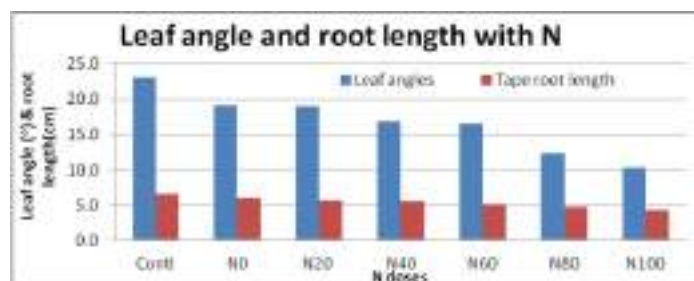


Fig 16 Effect of N levels on leaf angle and tap root length of coriander

#### Threshold level of P requirement of coriander (ACr-1)

Growth parameters viz. plant height, number of branches, yield & yield attributes and nutrient uptake was more with application of phosphorus, whereas harvest index was highest with 40 kg P/ha<sup>-1</sup>. Number of leaf, petiole length, chlorophyll content, number of root tips, total root length and average root diameter were also enhanced with P inputs, however, tap root length, root area and leaf angle was lowered with applied P (Fig17&18).

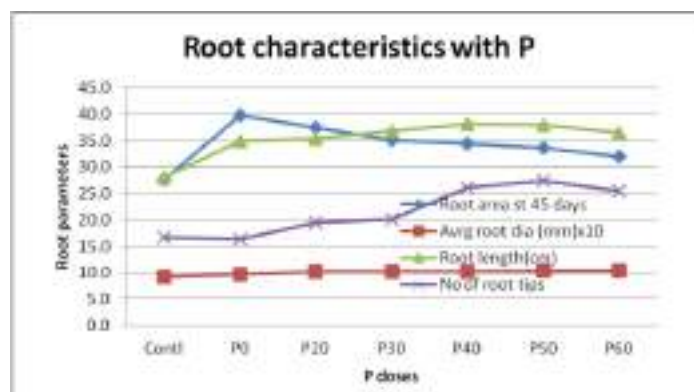


Fig 17 Effect of P levels on root characteristic of coriander

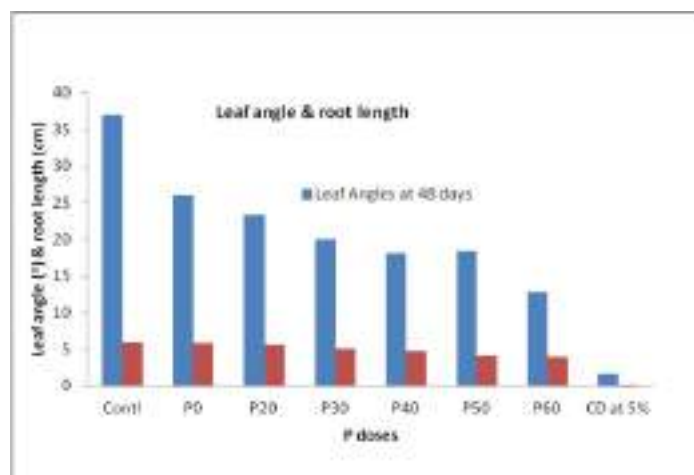


Fig 18 Effect of P levels on leaf angle and tap root length of coriander



### 5.10.2 Evaluation of seed spices for edaphic stresses

The experiment on cumin with compaction stress indicated that plant height and number of branches decreased with increased in compaction. However, compaction of BD 1.35 g cm<sup>3</sup> is critical for the growth particularly for plant height and number of branches per plant. Seedling mortality was also high with higher compaction (Fig 19). More than 90 per cent plants were died when the compaction goes to BD 1.78 g cm<sup>3</sup> and porosity went down less than 33.0 per cent.

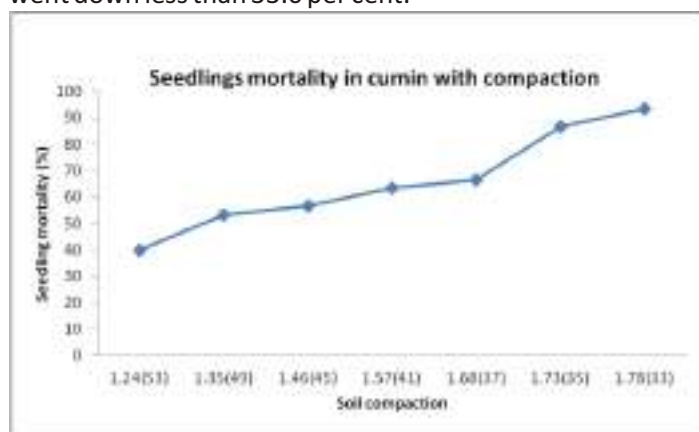


Fig 19 Influence of soil compaction on seedling mortality of cumin

### 5.11 Survey and surveillance of diseases of seed spices

#### 5.11.1 Survey and surveillance of existing and emerging diseases of seed spices

##### Survey on farmers fields

During *rabi* season of 2013-14, cumin, coriander, fennel and fenugreek field were surveyed in Ajmer, Nagaur, Jodhpur, Jaisalmer, Kota, Baran, Pratapgarh, and Sawai Madhopur districts of Rajasthan and Mandsaur district of Madhya Pradesh. In total 52 cumin fields at 20 locations in six districts, 10 coriander fields at 5 locations in one district, 16 fennel fields at 16 locations in three districts were surveyed (Table 5.22). It was observed that in cumin, blight (6-100%), wilt (0-78%), and powdery mildew (5-30%); in coriander, wilt (0-5%) and powdery mildew (0-50%); in fenugreek, powdery mildew (0-70%) and downy mildew (19-67%) and in fennel *Ramularia* blight (5-55%) and powdery mildew (0-80%) were prevalent in major growing areas.

Table 5.22 Prevalence of seed spice diseases on farmer's field

S. No	District	Seed spice crop	Major disease (no of fields Surveyed)	Disease Intensity
1	Ajmer (Raj)	Cumin Fenugreek Fennel	Blight (15) Powdery mildew (8) Ramularia blight (5)	Severe Moderate
2	Nagaur (Raj)	Cumin Fenugreek Coriander Fennel	Blight, wilt (14) Powdery mildew (9) Powdery mildew (3) Ramularia blight (6)	Severe Moderate to severe Low Moderate
3	Jodhpur (Raj)	Cumin Fenugreek	Blight, wilt (12) Powdery mildew (3)	Severe Moderate to severe
4	Kota (Raj)	Coriander Fenugreek	Nil (10) Powdery mildew (2)	Moderate to severe
5	Sawai Madhopur (Raj)	Cumin Fenugreek Fennel	Blight (2) Downy mildew (3) Ramularia blight (5)	Severe Moderate to severe Moderate
6	Pratapgarh (Raj)	Fenugreek Cumin	Powdery mildew (5) Blight, wilt (4)	Moderate Moderate
7	Mandsaur (MP)	Fenugreek Cumin	Powdery mildew (6) Blight, wilt (5)	Moderate Moderate



### Surveillance on the Institute farm

Six seed spices crops, viz. cumin (RZ 209), coriander (Ajmer Coriander 1), fenugreek (Ajmer Fenugreek 1) and fennel (Ajmer Fennel 1) was raised at the institute farm in the plot size of 3.0 x 3.0 m. Appearance and spread of different diseases was observed at weekly interval. In cumin, wilt disease was observed from early crop stage. The other diseases observed were blight and powdery mildew. During the season cumin blight was recorded in moderate to severe form (20- 86.5%) whereas powdery mildew on fenugreek (10-46.2%) and *Ramulria* blight on fennel was observed in moderate form. Powdery mildew on coriander was observed only upto 10%. The initial symptoms were appeared on fenugreek for powdery mildew at 88 DAS; on coriander for powdery mildew at 92 DAS; on cumin for blight at 85 DAS and on fennel for *Ramularia* blight at 110 DAS.

### **Alternaria leaf blight: a new disease of fenugreek (*Trigonella foenum-graecum*) caused by *Alternaria alternata***

In fenugreek experiment fields during the late winter of 2013, some plants exhibited leaf blight symptoms consisting of circular to irregular dark brown lesions with grayish centre on leaves with black sporulation, the small brown lesions gradually coalesced to form a large one covering leaf margins and ultimately the leaves withered and dropped.

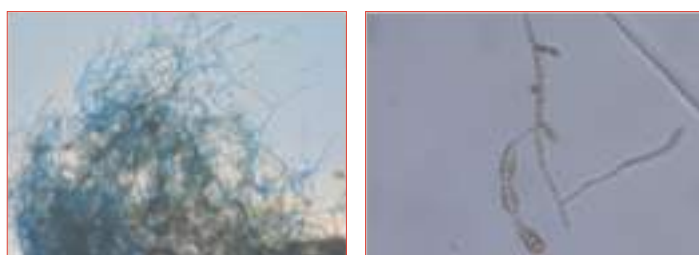
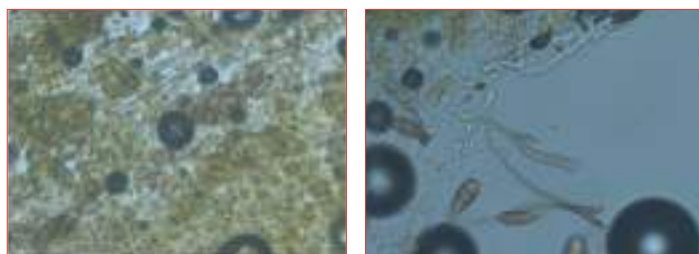
The disease symptoms were predominant during the month of February-March. *Alternaria alternata* fungus was consistently isolated when sections of diseased leaf were surface sterilized (2% sodium hypochlorite) and plated on potato dextrose agar (PDA). Colonies reached upto 90 mm diameter in 7 days at 25°C on PDA. The species was placed in the *Alternaria alternata*, and the identity was confirmed at Indian Agricultural Research Institute, New Delhi (ITCC 9058.13). Pathogenicity tests were done twice in detached leaf by spraying a conidial suspension ( $1 \times 10^6$  conidia  $\text{ml}^{-1}$  in sterile distilled water) on to the healthy leaves of 3 months old plants. Inoculated leaves and water sprayed controls were incubated at room temperature. Symptoms started developing on the inoculated leaves after 4-5 days. The pathogen was reisolated from the leaves of affected inoculated leaves to confirm Koch's postulates. The control plants did not exhibit the symptoms.



Leaf blight symptoms on fenugreek leaves



Pathogenicity tests in detached leaf



Mycelium, conidiophores and conidia in host cell and in culture

### 5.11.2 Survey and surveillance of insect pests of seed spices

Development of insect pests and natural enemies' complex on seed spice crops was recorded from early vegetative stages of plant to crop maturity. Among all selected crop for study, sucking pests were recorded as major pest in all crops. Among sucking pests aphids were



responsible for maximum crop damage followed by thrips. Other important pests recorded were seed wasp, jassids, leaf miner, and hoppers. Among natural enemies of pest predators Coccinells, aphid's parasitoids were most abundant. Honey bees were chief pollinators of crops and *Apis florea* was maximum visitor on seed spices crops.

In cumin aphids and thrips constitute major pests species. Thrips population was found more active in early vegetative stage up to January month. Aphids in cumin were recorded since January month and population peaked during 7<sup>th</sup> to 9<sup>th</sup> standard week. The activity of predator *Coccinella* and aphid's parasitoids was maximum during 6<sup>th</sup> to 9<sup>th</sup> and 7<sup>th</sup> to 9<sup>th</sup> standard week, respectively. Honey bees were remained active throughout flowering period of crops.

Similarly, aphids also constitute major pests of coriander, fennel and fenugreek crops and were found active from 4<sup>th</sup> to 13<sup>th</sup> standard week. *Coccinella* population were active from 7<sup>th</sup> to 14<sup>th</sup> standard week, aphids parasitoids population from 6<sup>th</sup> to 13<sup>th</sup> standard week and honey bees from 4<sup>th</sup> to 12<sup>th</sup> standard week.

**New alternate host of *Thrips* spp. Identified**

*Cenchrus ciliaris* commonly known as anjan grass or buffelgrass found abundantly in Rajasthan on bund of agricultural fields. It is also used to check soil erosion in semi arid areas. On survey of seed spice growing areas, *C. ciliaris* found an alternative host of thrips spp. during off season of seed spice crops. Thrips survive on this grass in absence of seed spice crops and shift on seed spice crops like cumin and fennel on early vegetative stages and when crop mature it leave again to weedy bund of buffle grass and survive on it till next preferable crop come in existence.



*Cenchrus ciliaris* weed and thrips

**New aphid species on cumin identified**

Aphids are major pest of cumin crop and are responsible for more than 50 percent loss of yield in unprotected crop. There are two type of aphid species *Apis craccivora* are black in colour and *Myzus persicae* are green in colour is found on cumin crop in all growing areas. During survey of insect pests of seed spice a new aphid species which was red and green in colour was found in area of Village Rampura and Ajgara of Ajmer district. On preliminary study it was found different than both reported species.



**5.12 Management of diseases in seed spices**

**5.12.1 Evaluation of *Trichoderma* isolates for the management of wilt (*Fusarium oxysporum* f.sp. *cumini*) disease of cumin**

The *Trichoderma* isolates Cu7-01, Cu7-02, Cu3-02, Cu9-02 along with *Trichoderma viride* were applied as seed treatment (ST) and soil application (SA) under pot and field conditions which showed significant efficacy against wilt disease of cumin. Comparatively, maximum reduction in wilt disease was observed with the application of isolates Cu 7-01, Cu3-02, Cu 7-02 and *T. viride* under pot conditions. When mixture of *Trichoderma* isolates were applied in different combinations, maximum reduction in wilt incidence was observed in Cu7-01 + Cu 7-02 and Cu3-02 + Cu7-01 + Cu7-02, however, mixture of isolates in all combination was at par for their effect.



Under field conditions, minimum wilt incidence was observed in the plots treated with Cu7-01 and combination of Cu7-01+Cu7-02 and Cu7-01+*T. viride*. All *Trichoderma* isolates enhanced the growth characters as compared to untreated control. Among the isolates, Cu7-01 showed maximum vigour index (Table 1).

Table 5.23 Effect of *Trichoderma* isolates on wilt incidence under field condition

Treatments	Wilt incidence (%)	% disease reduction
Cu3-0240.7 (39.6)29.7		
Cu7-01	35.9 (36.8)	38.0
Cu7-02	42.2 (40.5)	27.1
Cu9-02	41.4 (40.0)	28.5
Cu7-01 + Cu7-02	32.4 (34.7)	44.0
Cu7-01 + <i>T. viride</i>	33.7 (35.5)	41.8
<i>T. viride</i>	40.0 (39.2)	30.9
Carbendazim	41.7 (40.2)	28.0
Control	57.9 (49.6)	-
CD=0.05	(3.13)	

### 5.12.2 Management of wilt disease in cumin (*Cuminum cyminum*) through soil solarization

Total eleven treatments (T1 to T11) taken on sick plot. The maximum percent disease incidence (65.72) was found in control (without soil solarization). The minimum percent disease incidence (4.82) was found in the treatment 'T8' (20 days soil solarization + neem cake + *Trichoderma viride*) followed by the treatment 'T9' (30 days soil solarization + neem cake + *Trichoderma viride*) with PDI-4.97. Similarly the reduction in percent of pathogen population was maximum in T9 (75.91) followed by T8 (73.63) whereas the minimum reduction in pathogen population was recorded in T10.

Table 5.24 Effect of soil solarization, neem cake and *Trichoderma* on wilt disease of cumin

Treatments	Wilt incidence (%)				% disease reduction
	30 DAS	45 DAS	60 DAS	Mean	
T1 (SS for 10 days)	7.1	10.6	11.0	11 (3.46)	83.26 (9.18)
T2 (SS for 20 days)	2.3	7.9	8.6	8.6 (3.10)	86.91 (9.38)
T3 (SS for 30 days)	1.5	2.9	9.4	9.4 (3.22)	85.70 (9.31)
T4 (SS for 10 days +T)	3.1	11.5	10.4	10.4 (3.38)	84.18 (9.23)
T5 (SS for 20 days +T)	1.6	6.1	9.3	9.3 (3.21)	85.85 (9.32)
T6 (SS for 30 days +T)	4.4	5.6	7.8	7.8 (2.97)	88.13 (9.44)
T7 (SS for 10 days +T+NC)	2.5	4.7	7.4	7.4 (2.90)	88.74 (9.47)
T8 (SS for 20 days+T+NC)	1.2	3.9	4.8	4.82 (2.41)	<b>92.67</b> (9.68)
T9 (SS for 30 days+T+NC)	1.3	4.1	4.9	4.97 (2.44)	92.44 (9.67)
T10 (control)	56.9	84.7	65.7	65.72(8.17)	0.00 (1.00)
T11 (carbendazim)	45.0	41.0	41.9	41.97 6.56)	36.14 (6.09)
CD = 0.05				0.41	0.59

Note : SS=soil solarization, T=*Trichoderma*, NC = neem cake





Field view of cumin crop raised on sick plot after soil solarised

### 5.12.3 Fungicide schedule for the management of cumin blight

For the management of Alternaria blight disease of cumin, fungicides application was scheduled in different combinations at 15 days interval based on the appearance and spread of the disease under field conditions. All

Table 5.25 Effect of fungicide schedules on blight disease of cumin

Treatment	Blight PDI	Percent disease reduction
T1- One spray of chlorothalonil followed by two sprays of propineb	29.7 (33.0)	31.0 (33.6)
T2- One spray of chlorothalonil followed by two sprays equation pro	24.7 (29.8)	42.6 (40.6)
T3- One spray of chlorothalonil followed by two sprays azoxystrobin	19.0 (25.8)	55.8 (48.0)
T4- One spray of chlorothalonil followed by two sprays propiconazole	22.0 (27.9)	48.8 (44.2)
T5- One spray of propineb followed by two sprays of equation pro	21.0 (27.3)	51.2 (45.4)
T6- One spray of propineb followed by two sprays of azoxystrobin	21.3 (27.5)	50.4 (45.2)
T7- One spray of propineb followed by two sprays of propiconazole	24.7 (29.8)	42.6 (40.7)
T8- One spray of mancozeb followed by two sprays propiconazole	22.3 (28.2)	48.1 (43.8)
T9- Control	43.0 (41.0)	-
CD=0.05	(2.80)	(5.11)

fungicide schedules reduced the blight PDI compared to untreated control (Table 5.25).

Among the treatments, minimum blight PDI was observed with the application of chlorothalonil followed by two sprays of azoxystrobin. This was at par with application of chlorothalonil followed by propiconazole (T4), propineb followed by equation pro (T5), propineb followed by azoxystrobin (T6) and mancozeb followed by propiconazole (T8). Hence, application of chlorothalonil followed by two sprays of azoxystrobin or propiconazole could be effective fungicide schedule for the management of cumin blight.

### 5.12 Management of insect pests in seed spices

#### 5.12.1 Management of seed insect-pest of seed spices through modified atmospheric packaging and other non chemical methods

Study of Modified Atmospheric Packaging (MAP) using different inert gases alone and in combination in aluminium foil of 1000 micron gauge for control of *Lasioderma serricorne* beetle in cumin and ajwain seed showed that all the treatments were highly effective in control of beetle population as no insects were survived in inert gases. Total and essential oil were also found higher and microbial load was found lower in most of the treatment as compared to control. Maximum total oil contents in ajwain seeds was found in seed packed with O<sub>2</sub> alone and in cumin, seed packed with CO<sub>2</sub> alone. Essential oil content in ajwain seed was maximum in seed packed in vacuume and in cumin seed packed with N<sub>2</sub> alone. In ajwain total fungal count was lowest in treatment of O<sub>2</sub> alone and N<sub>2</sub> (50%) + O<sub>2</sub> (50%), whereas total essential oil content was maximum in treatment of CO<sub>2</sub> (50%) + N<sub>2</sub> (50%).

For non chemical method of control of beetle population, use of Diatomaceous earth @ 0.2% both in cumin and ajwain seed showed maximum mortality of beetle and minimum damage of seeds and also lower microbial loads. Total oil contents were slightly lower in most of treatments where as essential oil content was higher in Alum salt treatments in both seeds.

Impregnation of 1.0% w/v own seed oil on cumin and ajwain seed resulted maximum protection against beetle population. In case of ajwain seed packed in closed



container and in cumin packed in polythene found most effective against pest. In closed container total and essential oil content was found maximum and microbial load was minimum in both cumin and ajwain.

### 5.13.2 Management of fennel seed wasp (*systole albipennis walker*)

Management of seed wasp in fennel crop using agronomical modification, botanicals and insecticidal application showed various level of protection from fennel seed wasp. Sowing of fennel crop on 1<sup>st</sup> September and 15<sup>th</sup> September reduced maximum seed damage. Inter cropping of fennel with dill in ratio of 2:1 found most effective in reduction of seed wasp damage (3.18%). In botanicals soil application of karanj meal @ 500kg/ha and subsequent three spray of kanranj oil @ 2.0% at 15 days interval from flowering initiation showed maximum protection against seed wasp damage (2.87%) against control (7.04%). Total microbial load in rhizosperic soil at harvest (fungal and bacterial) were also recorded maximum in same treatment. Application of systemic granular insecticide as soil incorporation at different time of sowing showed that clothianidin @1.0 kg ai/ha at 120 DAS gave maximum protection (0.89%) against pest control (11.34%). Effect of botanicals was also observed against *Ramularia* blight of fennel with absolute control. Castor oil 2% was found most effective (PDI 12) as compare to control (PDI 23). In most of the treatments where fennel raised with inter crop, the disease occurrence was more as compared to the control (sole crop) except the inter cropping of fennel with maize (3:1) and rai (3:1) where disease (PDI 30.5) reduced slightly compared to control.

### 5.13.3 Field evaluation of insecticides/ botanicals against seed midge, *Systole albipennis Walker* (Hymenoptera: Eurytomidae) infesting fennel (AICRP Programme)

Field experiment on fennel crop was conducted on management of seed midge in fennel at experimental farm of NRCSS. Among eight treatments applied as foliar spray, application of Neem Seed Kernel Extract ( NSKE) @5.0% was found most effective in control of population at field

level( 9.79% seed damage).However, maximum yield of 25.11 q./hac was obtained in application of Deltamethrin 0.003%.

Table 5.26 Field evaluation of insecticides/ botanicals against seed midge, *Systole albipennis Walker*

S. No.	Treatments	Average Seed/Umbel	Damaged Seed	% Damage	Yield Q./ha.
T1	NSKE-5%	382.00	(19.52)	37.40	(6.20)
		9.79	17.05		
T2	Cartap H. Chloride 50 SP @0.15%	483.75	(21.95)	59.15	(7.76)
		12.27	20.70		
T3	Spinosad 45SC @ 0.01%	476.63	(21.71)	73.90	(8.65)
		15.50	17.36		
T4	Abamectin 1.9EC @ 2 ml/lit.	496.70	(22.22)	73.00	(8.60)
		14.69	21.37		
T5	Achook 3 ml/lit.	495.75	(22.04)	53.00	(7.35)
		10.69	18.67		
T6	Acetamiprid 20 Sp @ 0.004%	842.80	(28.62)	47.20	(6.94)
		5.60	27.70		
T7	Deltamethrin 0.003%	490.45	(22.13)	79.30	(8.96)
		16.16	25.11		
T8	Untreated Check (Control)	535.20	(22.86)	120.50	(11.02)
		22.51	13.09		
	CD @ 5%	5.21	3.05	4.34	

### 5.14 Biochemical basis of defence mechanism and quality traits in seed spices

#### 5.14.1 Quality profiling of coriander and fenugreek germplasm

Nineteen genotypes of coriander and 16 genotypes of fenugreek were evaluated for quality attributes including medicinally active compounds. Volatile oil content in intact seeds, GC-MS profiling, oleoresin content of ground seeds, Total Phenolic Content (TPC), Total Flavonoid Content (TFC), total antioxidant content, galactomannan content, saponine, diosgenine content have been evaluated (Table 5.27, 5.28 & 5.29). All the genotypes showed a positive relation in TPC/TFC with antioxidant content. Fatty acid methyl esters of fenugreek showed large variation between genotypes.



Table 5.27 Medicinal and industrial attributes analysis in fenugreek genotypes

Medicinal and industrial attributes	Range	AV	ST	DEV
Sapogenin (%)	6.00	8.34	6.958	0.623
Diosgenin (%)	0.33	0.82	0.541	0.155
Total Phenolic content (%)	0.029	0.059	0.041	0.008
Total Flavonoid Content (%)	0.096	0.220	0.168	0.027
Antioxidant Activity (mg/gm BHTE/crude extract)	82.36	110.24	97.910	8.018
Galactomannan (%)	25.50	28.21	27.099	0.812

Table 5.28 Fatty oil and fatty acid analysis in fenugreek genotypes

Fixed oil and fatty acids	Range	AV	ST	DEV
Fixed oil (%)	4.26	11.62	6.73	2.16
Palmitic acid (%)	5.09	13.81	10.69	3.67
Linoleic acid (%)	29.46	44.17	39.17	3.67
Stearic acid (%)	2.86	7.63	5.64	1.62
Eicosanoic acid	1.39	2.77	1.99	0.41

Table 5.29 Fatty oil and medicinal attributes in coriander genotypes

Attributes	Range	AV	STDEV
Fixed oil (%)	5.95 - 10.66	7.967	1.621
Volatile oil (%)	0.082 - 0.228	0.141	0.047
Total Phenolic content (ppm)	10.24 - 39.68	29.780	9.360
Total Flavonoid Content (ppm)	14.25 - 24.9	18.710	2.910
Antioxidant Activity (mg/gm BHTE/crude extract)	14.25 - 18.83	15.90	1.200

### 5.14.2 Biochemical basis of defense mechanism in cumin (*Cuminum cyminum* L.)

Four antioxidants (Ascorbic acid, Salicylic acid, Jasmonic acid and Benzoic acid) were taken with two levels i.e. 100 and 200 ppm. Antioxidants applied by seed soaking and foliar spray. Germination percentage was observed maximum in T2 GC 4 (V1) and T4 of RZ 209 (V2) while, minimum germination was observed in control plants of both cumin genotypes. Mortality at 30 DAS due to wilt disease, at 60 DAS due to blight disease and 100 DAS due to repeated wilt and blight disease was significantly affected by antioxidant treatments. All the results were significant within treatments and their combinations with genotypes. Germination percentage and seedlings health improves with the use of antioxidant treatments as compare to control. Plant defense related bio-molecules, total phenol and flavonoids were found in leaf and root tissues. These AO can be effective bio-alternates for harmful fungicides and chemicals.

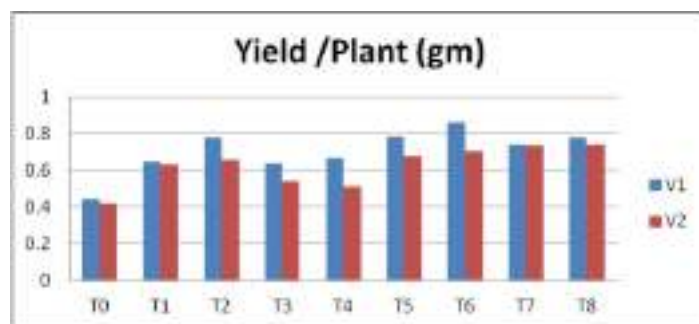


Fig 20 Effect of antioxidants on seed yield of cumin

### 5.15 Physiological approaches for enhancing yield and quality in seed spices under abiotic stresses

This project was initiated during 2012-13. Problem of delayed germination in cumin was addressed utilizing physiological approaches i.e. seed priming. Seeds of cumin genotype GC 4 were primed with selected chemicals including PGRs and antioxidants. All the treatments showed germination initiation on 5<sup>th</sup> Days After Inoculation (DAI) under *in vitro* conditions. Treatments of Salicylic Acid 5 µM, Betain HCL 3, 5 µM, Proline 200, 400 and 600 µM Benjoic Acid 100 ppm, Ascorbic Acid 100, 300 ppm and PVP 100, 200 ppm showed more than 50% germination on 8th DAI. On 12<sup>th</sup> DAI, except Thiourea 1000 ppm and Benjoic acid 300 ppm all treatments showed significantly more germination% as compare to control. The experiment was replicated under field conditions where treatments of Benjoic Acid 100 ppm, Ascorbic Acid 200 ppm, PVP 200, 300 ppm, KH<sub>2</sub>PO<sub>4</sub> 0.75%, 1.0%, Betain hydrchloride 7 µm, PEG (8000) 10%, 20%, Citric acid 300 ppm, Proline 600 µm + Betain hydrchloride 7 µm showed better results as compare to control. Exogenous application of Glycine 400 uM, Paczee 3uM, Proline 200uM, Proline 400uM resulted in significant increase in seed yield of cumin genotype GC 4. Total oil, essential oil, total phenolic content and total flavonoid content of elite cumin genotypes were estimated to find out their effect of seed germination. Significant difference was observed in essential oil and total oil % of selected cumin genotypes. Genotypes with more total oil showed less germination. However, no relation of essential oil % with germination was observed. Genotypes showing less flavonoid content and moderate phenolics were showing more germination as compare other genotypes (Table 5.30).



Table 5.30 Total oil, essential oil, total phenolics contents (ppm GAE / 1000 ppm crude seed extract ) and total flavonoid contents (ppm QE/ 1000 ppm crude seed extract) of cumin genotypes

Genotypes	Essential oil (%)	Total oil (%)	TPC	TFC	Germination after 8 <sup>th</sup> DAI
GC 4 (UT)	3.31	20.34	58.965	24.98	6(11)
GC 4 Pelleted	2.20	9.68	41.734	7.209	62(89)
GC 4 Treated	4.65	13.12	33.528	14.893	-
GC 4	2.90	18.33	46.35	12.03	11(32)
Cumin-9	2.65	11.72	48.298	15.95	11(17)
Cumin 13	2.99	13.56	22.554	5.123	30(56)
Cumin 12	2.66	14.70	48.503	17.164	31(62)
Cumin 11	2.98	13.02	47.785	16.636	46(84)
RZ 19	2.68	16.08	51.067	23.739	8(15)
RZ 209	2.80	17.33	48.36	21.23	7(39)
Cumin 10	1.65	13.22	54.542	15.95	44(84)

## 5.16 Seed spices knowledge management and technology transfer

### 5.16.1 Design and Development of Database for Seed Spices:

In Database of seed spices, further addition of information on domestic and international prices of seed spices and other spices crops and their comparison had been done. Net trade of the seed spices were found positive. There were price fluctuations of domestic and international prices of seed spices. All data had been compiled and module had been developed to access the information. Recent data on area, production and productivity of states and competitive crops had also been added (Fig.24).

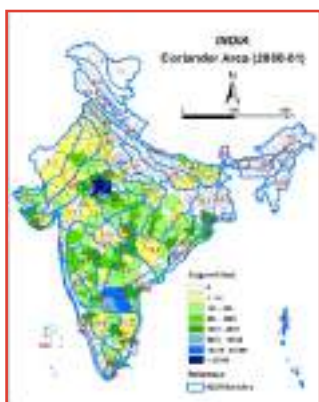


Fig 21. Scenario of area under coriander for year 2000-01



Fig 22. Scenario of area under celery for year 2000-01

### 5.16.2 Development of seed spices atlas of India using GIS approach:

In continuation to earlier work, data on APY considering reference year as 2000-01 from state horticulture and agriculture departments (especially directorate) of Haryana, Punjab, Uttar Pradesh, Uttarakhand, Bihar and Karnataka were collected and all the data had been compiled, cleaned, and integrated with existing GIS database. Then map had been created for the respective state with analysis of data and track change studies. The map of overall India had been prepared for the same database. Also AESR (Agro Ecological Sub Region) Map developed for available data for India and seed spices grown in particular regions identified.

### 5.16.3 Awareness and adoption of seed spices production technology

Nine training programmes on production technology of seed spices were conducted in selected districts covering 180 participants (Table 5.31) in the cropping season.

Table 5.31 Number of trainings on seed spices production technology in selected districts (2012-13)

S. No.	District	Number of training	Number of participants
1.	Ajmer	6	80
2.	Jodhpur	1	30
3.	Baran	2	70
	Total	9	180

### Performance of cumin demonstrations

Average yield was obtained from cumin variety GC 4 in Ajmer and Jodhpur districts was 7.50 and 5.70 q/ha, respectively as compared to local cumin variety, which gave 4.80q/ha and 4.30 q/ha seed yield in Ajmer and Jodhpur district respectively. Increase in yield due to combined effect of seed, fungicide, weedicide and fertilizers in Ajmer and Jodhpur for cumin crop was 56.25 % and 55.81 %, respectively. The B:C ratio of cumin in Ajmer and Jodhpur was 4.00 and 3.40, respectively.



### Performance of coriander demonstrations

Average yield of coriander (RCr-436) in demonstrations was 14.80 q/ha in Baran district as compared to average yield of local variety (10.80 q/ha). Increase in yield due to combined effect of seed, weedicide and fungicide was 37.00 % higher in RCr-436. The B:C ratio for coriander crop under demonstration was 2.86



Tehsil Masuda, Ajmer



Demonstration of cumin in village Ratakot  
Tehsil Masuda, Ajmer

### Impact of the technology

Impact analysis was done by selecting 10% of the total beneficiaries in Ajmer, Jodhpur and Baran districts of Rajasthan and found that the knowledge level of beneficiaries increased in Ajmer from 43.41 to 57.41% in cumin production technologies while adoption level increased from 31.32 to 40.91%. Likewise in Jodhpur district it was found that knowledge level increased from 44.48 to 56.41% and adoption level from 33.34 to 40.07% in cumin crop. Further in Baran district, it was found that the knowledge level increased from 45.34 to 56.42% and

adoption level increased from 31.61 to 40.62% for coriander production technologies.

### 5.17 Externally funded Project

#### 5.17.1 Value chain in major seed spices for domestic and export promotion (NAIP Component-II)

Coriander varieties namely ACr-1, RCr-41, RCr-435, and RCr-436 and fenugreek varieties AFg-1, AFg-2 and AFg-3 were identified for higher yield and quality. Large scale multiplication AFg-3 (fenugreek) being done at farmer fields. 1500 kg seed was produced at farmer's field.

Thirty three demonstrations on seed treatment, improved varieties and good agricultural practices like line sowing in coriander, fenugreek and cumin were carried out with the farmers of Ajmer, Barmer, Jaisalmer, Jaipur and Nagaur districts. The yield increased by the given interventions was in the range of 17 to 36 % over local practices.

Coriander has given highest yield (533.75 kg/ha) with 60 kg/ha nitrogen and boron spray of 0.6 %, whereas fenugreek has exhibited maximum yield (969.16 kg/ha) with 30 kg/ha N and boron spray of 0.5 %. Soil application of Mg (15 kg/ha) with foliar application of Mn (0.6 %) exhibited highest yield of coriander (620.83 kg/ha) and fenugreek (900.84 kg/ha).

Performance of solar dryer for drying of green pods and grain of fenugreek was better, which exhibited maximum recovery percent with better color, texture and taste. Coriander and fenugreek grain can be stored safely in aluminum vacuum bags, where minimum moisture% (7.65,7.15) with lowest insect count(14.1) and highest seed viability% (89.92) was recorded.

#### 5.17.2 Studies on cryogenic grinding for retention of flavor and medicinal properties of some important Indian spices (NAIP Component IV)

Effect of cryogenic grinding technology on enhancing analgesic and antipyretic activities of coriander seed extract have been analyzed. Seed extracts of both the genotypes, RCr 436 and Sudha showed considerable analgesic and antipyretic activities. Results indicated that seed extract of cryo ground seeds were more effective than non cryo ground seeds and RCr 436 was more effective than genotype Sudha. Seed extract of non cryo ground seeds of



genotype RCr 436 when administered as drug was able to reduce the rectal temperature by  $0.33^{\circ}\text{C}$  after 5hrs while seed extract of cryo ground seeds of genotype RCr 436 was able to reduce the rectal temperature up to  $0.6^{\circ}\text{C}$  which was at par with paracetamol-150 where rectal temperature was reduced up to  $0.85^{\circ}\text{C}$  after 5 hrs. It could be concluded that medicinal quality of coriander and similar herbs to can improve significantly by adopting cryogenic grinding technology in ayurveda and other natural therapies for various ailments.

Rats of group I served as control, the rectal temperature of control group rats was ranging from  $37.65\pm 0.11$  to  $38.45\pm 0.03^{\circ}\text{C}$ . Standard drug paracetamol @

$150\text{mg}/\text{kg}$  bw, p.o. was able to decrease the rectal temperature up to  $37.8^{\circ}\text{C}\pm 0.11$  after 1 hr of administration and come down to the level of  $37.6^{\circ}\text{C}\pm 0.06$  after 5 hrs. Seed extract of non cryo ground seeds of genotype RCr 436 when administered as drug was able to reduce the rectal temperature from  $38.53^{\circ}\text{C}\pm 0.09$  at 0 hr to  $38.2^{\circ}\text{C}\pm 0.09$  after 5hrs. However, seed extract of cryo ground seeds of genotype RCr 436 was showing at par results with paracetamol-150 being observed  $37.90^{\circ}\text{C}\pm 0.07$  after 3 hrs and  $37.74^{\circ}\text{C}\pm 0.03$  after 5 hrs. Similar results were obtained with genotype Sudha. Among both the genotypes RCr 436 was found more effective in both analgesic and antipyretic activity.

Table 5.32 Analgesic activity of seed extract of coriander genotype RCr 436

Treatment/ Dose (mg/kg)	Average tail withdrawing time in second						
	0 min	30 min	60 min	90 min	120 min	180 min	240 min
Only vehicle	$1.26\pm 0.05$	$1.28\pm 0.042$	$1.28\pm 0.04$	$1.27\pm 0.05$	$1.29\pm 0.05$	$1.30\pm 0.047$	$1.32\pm 0.03$
Pentazocine -10	$1.30\pm 0.12$	$2.00\pm 0.05$	$3.73\pm 0.12$	$3.35\pm 0.09$	$2.86\pm 0.15$	$2.23\pm 0.14$	$1.73\pm 0.13$
Seed extract (NC)	$1.31\pm 0.07$	$1.35\pm 0.07$	$2.41\pm 0.09$	$2.08\pm 0.22$	$2.0\pm 0.14$	$1.70\pm 0.14$	$1.55\pm 0.08$
Seed extract (C)	$1.44\pm 0.11$	$1.64\pm 0.10$	$2.66\pm 0.17$	$3.01\pm 0.33$	$2.85\pm 0.27$	$2.68\pm 0.19$	$2.41\pm 0.11$

Table 5.33 Antipyretic activity of seed extract of coriander genotype RCr 436

Treatment/ Dose (mg/kg)	Average tail withdrawing time in second							
Disease	-18 hrs	0 hrs	½ hrs	1 hrs	2 hrs	3 hrs	4 hrs	5 hrs
Control	37.65	38.56	38.6	38.63	38.65	38.63	38.43	38.45
Paracetamol - 150	$\pm 0.11$	$\pm 0.17$	$\pm 0.17$	$\pm 0.17$	$\pm 0.17$	$\pm 0.16$	$\pm 0.03$	$\pm 0.03$
Seed extract (NC)	37.58	38.45	38.47	37.8	37.7	37.67	37.61	37.6
Seed extract (C)	$\pm 0.07$	$\pm 0.11$	$\pm 0.12$	$\pm 0.11$	$\pm 0.09$	$\pm 0.06$	$\pm 0.07$	$\pm 0.06$
Seed extract (NC)	37.47	38.53	38.52	38.49	38.4	38.32	38.24	38.2
Seed extract (C)	$\pm 0.07$	$\pm 0.09$	$\pm 0.09$	$\pm 0.09$	$\pm 0.08$	$\pm 0.07$	$\pm 0.09$	$\pm 0.09$
Seed extract (C)	37.48	38.3	38.27	38.23	38.05	37.90	37.76	37.74
Seed extract (C)	$\pm 0.06$	$\pm 0.07$	$\pm 0.06$	$\pm 0.07$	$\pm 0.07$	$\pm 0.07$	$\pm 0.04$	$\pm 0.03$



### 5.17.3 DUS Project

Two consecutive meetings of task force of PPV and FRA New Delhi were held to finalize the DUS guidelines for coriander and fenugreek developed at NRCSS. The task force approved the guidelines which have been published in Plant Varieties Journal of India Vol.07, No.03, 01 March, 2013 and notification S.O.1093 (E) dt.15 April 2014 was published in the Gazette of India can be downloaded from the Authority's website, the relevant link <http://www.plantauthority.gov.in/crop-guidelines.htm>.



### 5.17.4 Management of pest and diseases of seed spices using bio control products through on farm demonstration at farmer's field (DBT, New Delhi)

Demonstration of biocontrol products were conducted for management of diseases and insect pests of seed spice crops of Cumin, Coriander and Fennel at farmers field of Ajmer district. Total 187 farmers of 19 villages in 5 development block were selected. Biocontrol products *Trichoderma viride* against wilt (As seed treatment and soil application mixed with FYM), *Verticillium lecanii* and Neem oil for management of aphids for one acre area were given to each farmer selected for demonstration. Training to the farmers was given for scientific use of these products at their respective villages. A two days Training to the farmers was also organized at centre for application of bio control agents for pest and diseases management in seed spices. In this training locally manufactured/ formulation of biocontrol products was given for pest and diseases control.



### 5.17.5 Identification of plant growth promoting rhizobacterial inoculant for enhancing productivity of Isabgol (DBT)

Seventy rhizobacterial isolates has been made based on their ability to grow on specific media viz; nitrogen free media such as *Azotobacter* isolation media, King's B media, Pikovskaya media and Nutrient Agar media. These isolates have been tested for their IAA production potential, phosphate solubilization potential and ability to promote germination of Isabgol seeds in lab conditions. Three bacterial isolates (IBS-5, IBS-9 and IBS-28) were selected from the previously isolated rhizobacterial strains obtained from isabgol crop fields located in Jalore, Jodhpur and Barmer districts of Rajasthan. Strain ISB-5 is identified as *Azotobacter vinelandii*, ISB-9 identified as *Pseudomonas* spp., and ISB-28 as *Bacillus megaterium* on the basis of phenotypic, morphological, physiological, biochemical and molecular characteristics based on 16S rDNA sequencing. Strain ISB-5 and ISB-9 are Gram negative, semi-translucent, smooth mucoid colonies on nutrient agar plates. Strain ISB-28 is Gram positive and spore forming. All of them grew fast and showed positive oxidase activities. Strain ISB-5 and ISB-9 were able to growth in pH rage 5.0-9.0 and tolerated 4% NaCl. Strain ISB-9 also grows up to 45°C temperature. Previously isolated strains of rhizobacteria have been



applied on isabgol seeds to assay the growth promoting attributes on germination and seed vigour in lab conditions. These 03 rhizobacterial strains have been applied as PGPR in previous cropping season and encouraging results have been obtained for seed germination, early seedling establishment and growth. Application process standardization of these efficient PGPR strains (as single/consortium) through seed coating on Isabgol seeds has been standardized. At present the research work has been completed with the all objectives of the sanctioned project and final report of the project is under preparation.

#### 5.17.6 Intellectual Property Management and Transfer/Commercialization of Agricultural Technology Scheme

##### One day training-cum-awareness programme on Protection of Plant Varieties and Farmer Rights

A farmers' training programme on Protection of Plant Varieties and Farmer's Rights was organized on 30-09-2013 at NRCSS, Tabiji, Ajmer (Rajasthan) sponsored by Protection of Plant Varieties & Farmer's Right Authority, Govt. of India, New Delhi. A movie on Krishak Adhikar Krishi Ka Vikas (Hindi) showed to farmers. Dr. Balraj Singh, Director, NRCSS delivered a lecture on किसानों के लिए लाभदायक पौधा किस्म और कृषक अधिकार संरक्षण अधिनियम . Dr. R. S. Meena and Dr. R. K. Kakani, Principal Scientist (Plant Breeding), NRCSS delivered lecture on “कृषि एवं जैव विविधता का संरक्षण”, then Dr. Sharda Choudhary, Scientist (Biotechnology), NRCSS delivered lecture on “पौधा किस्म और कृषक अधिकार संरक्षण प्राधिकरण से अपेक्षाएँ ” and then last lecture delivered by Dr. R. K. Solanki, Scientist (Plant Breeding) on “पौधा किस्म और कृषक अधिकार संरक्षण अधिनियम के अंतर्गत संरक्षित फसलें” in this training cum awareness programme.

Total 101 participant attended the training programme among that 39 ladies farmers, 9 students, 2 agriculture supervisors and remaining were farmers, NGOs and scientists from different district of Rajasthan. Farmers were made aware of variety registration and farmer rights.

##### Lecture on IPR during short course

A lecture on Intellectual Property Rights in Agriculture was arranged during ICAR sponsored short course on “Hi-tech interventions in seed spice production for enhancing productivity, nutraceutical quality and value-addition” conducted during 3 to 12 October, 2013. The lecture was delivered by Ms. Yogmaya, Patent Attorney at Zonal Business Planning Division, Indian Agricultural Research Institute, New Delhi. Apart from participants of short course the lecture was attended by all scientific and technical staff of NRCSS.

##### NRCSS logo registered

The applications of registration of NRCSS logo have been filed to Controller General of Patents, Designs and Trademarks, Govt of India. NRCSS is now authorized to use™ symbol next to the logo.



### 5.17.7 Seed production

Table 5.34 Breeder seed produced during 2012-13 at NRCSS, Ajmer

Crop	Variety	DAC Indent	Production (kg)
Coriander	Ajmer Coriander-1	Nil	458
Fennel	Ajmer Fennel-1	Nil	386
Fenugreek	Ajmer Fenugreek-1	Nil	756
Fenugreek	Ajmer Fenugreek-2	Nil	103
Fenugreek	Ajmer Fenugreek-3	Nil	709
Ajwain	Ajmer Ajwain-1	Nil	142
Ajwain	Ajmer Ajwain-2	Nil	27
Dill	Ajmer Dill-1	Nil	87
Dill	Ajmer Dill-2	Nil	110
Nigella	Ajmer Nigella-1	Nil	10
Anise	Ajmer Anise-1	Nil	23

During 2012-13 TFL seed production of improved variety of cumin was taken at Farmer's field under Farmer's Participatory Seed Production Programme. The production details are as under:

S. NO.	Crop	Variety	Production (Quintals)
1.	Cumin	GC-4	41.08
		Total	41.08

### 5.18 AICRP Programme

#### 5.18.1 Intercropping of Seed Spices in vegetables (AICRP on Vegetable)

Three seed spices viz. fennel, ajwain and coriander with three vegetables viz. pea, cabbage and carrot were taken in 1:1 intercropping ratio. Based on two years study it is concluded that all the vegetables performed better with fennel compared to ajwain and coriander and resulted higher vegetable yield. Intercropping of seed spices with

carrot resulted in higher yield of fennel, coriander and ajwain compared with cabbage and pea. Among the entire intercropping pattern, fennel with cabbage resulted in highest fennel equivalent yield (30.59 q/hac) and net return (Rs 151160/- per/hac) followed by carrot + fennel. The highest benefit cost ratio of 4.66 was obtained in cabbage + fennel intercropping followed by with cabbage + Ajwain.



S. No	Treatment	Yield q/ha Vegetables (fresh)	Seed spice	Fennel equivalent yield (q/ha)	BCR
1	Pea+ Fennel	25.96	15.25	21.22	3.52
2	Pea+ Coriander	22.12	7.55	11.31	1.56
3	Pea +Ajwain	24.28	7.45	15.47	2.86
4	Cabbage+ Fennel	140.34	13.25	30.59	4.66
5	Cabbage +Coriander	103.67	7.69	18.75	2.68
6	Cabbage +Ajwain	120.80	7.35	24.66	4.24
7	Carrot+ Fennel	92.99	14.75	25.27	4.16
8	Carrot +Coriander	78.56	7.93	15.86	2.42
9	Carrot + Ajwain	84.32	7.65	20.15	3.77
	CD(P=0.05)	9.22	0.88	2.38	0.44



## 6. Technology Assessed and Transfer

The centre is also involved in transfer of proven technologies by conducting training programmes and demonstration of new varieties and production technologies. Seed spice growers and other stakeholders are attended by the experts of relevant subjects and provided with the literature on production technology of seed spices crops. Field visits, demonstrations and farmers training programmes are organized in collaboration with KVK, State Department of Agriculture/Horticulture and other extension agencies for dissemination of latest technologies. During the reporting year following activities have been carried out by NRCSS.

### 6.1 Dissemination of Seed Spices Production Technology under National Horticulture Mission

Front Line Demonstrations (FLDs) on improved production technology of fenugreek, cumin and coriander were conducted at Ajmer, Pali, Jhunjhunu, Nagaur, Sikar, Baran, Barmer and Jaisalmer districts of Rajasthan. Apart from FLDs, two farmer's training programmes were also organized. A two days farmer's training programme on "Enhancing production, productivity and quality of seeds spices in Shekhawati region" was organized during 7-8<sup>th</sup> November, 2013 at KVK, Jhunjhunu (Rajasthan) and another

practices. In both the training programmes, technical bulletin entitled "Bijya Masale- Kisano Ki Unnati Ka Aadhar" was provided to participant farmers. A total of 136 farmers (60 at KVK Jhunjhunu and 76 at KVK Pali) participated in the trainings.



Farmers training at KVK, Pali under NHM



Field visit of FLDs



Farmers training programme at KVK Jhunjhunu under NHM two days farmer's training programme on "Production and post-harvest management of seed spices" was organized during 6-7<sup>th</sup> March, 2014 at KVK, Pali (Rajasthan). Farmers were advised by different subject matter specialists for adoption of improved varieties and scientific cultivation

### Intrastate training programme on 'Improved Production Technologies of Seed Spices

'A two days training programme was organized for the farmers of Zila Parashid, Jaisalmer during 30 - 31 October, 2013 at NRCSS, Ajmer. More than forty farmers were participated. Lectures were delivered on crop improvement, crop production, crop protection, safe storage of seed spices, protection of plant variety and farmer's right, off season production of seed spice crops and mechanization possibilities in seed spices.



## 6.2 Technology transfer in North Eastern Hill Region

NRCSS has initiated technology transfer activities in North Eastern Hill region covering two states namely Arunachal Pradesh and Assam for crop diversification in favour of seed spices for enhancing area and production of seed spices in NEH region. A two days farmers training programme was conducted on “Promotion of seed spices production in Arunachal Pradesh” during 18-19 November, 2013 at College of Horticulture and Forestry, Pasighat (Arunachal Pradesh). Another two days farmers training programme on “Promotion of seed spice production in Assam” was conducted on 21-22 November, 2013 at Regional Station, CPCRI, Kahikuchi, Guwahati (Assam). In both the training programmes, 110 farmers (55 at Pasighat and 55 at Kahikuchi) have participated. Training was imparted on improved package of practices of seed spice production specifically, improved varieties, organic seed spice production, possibilities of intercropping of seed spices with fruit trees grown in NEH region and value addition in seed spices. Besides, training was also imparted on safe storage and handling of seed spices and horticultural produce for enhancing storability and quality of seed spices. A book on Hi-tech Horticulture was also provided to the farmers as well as faculty of College of Horticulture and Forestry Pasighat (Arunachal Pradesh) and Regional Station CPCRI, Kahikuchi, Guwahati (Assam).

In addition to this, 220 (110 in Arunachal Pradesh and 110 in Assam) demonstrations on coriander, fenugreek, ajwain and nigella were conducted in NEH region to test the feasibility and performance of seed spices. In Assam, plastic crates were also given to farmers for safe handling of seed spices and other horticultural crops.



Two days farmer's training at CHF, Pasighat (Arunachal Pradesh)



Trainees of Assam state at CPCRI-Regional Station, Kahikuchi (Assam)



Distribution of plastic crates to the farmer women Kahikuchi, Guwahati (Assam)

## 6.3 Technology transfer activities under Tribal Area Sub-Plan

NRCSS initiated the work in three districts of Rajasthan dominated by tribal population viz., Dungarpur, Banswara and Pratapgarh under Tribal Area Sub Plan (TSP) for crop diversification in favour of seed spices. In order to make aware the tribal people, three farmer's training on *Unnat Bijya Masalo Ki Kheti* were conducted with the help of KVK Dungarpur, KVK Banswara and KVK Pratapgarh on 17, 18 and 19 October, 2013 respectively. In all three training programmes, farmers were educated about the importance, prospects and potential of seed spice production in tribal areas.





Farmers training at KVK, Dungarpur



Farmers training at KVK Banswara under TSP



Distribution of seeds for FLDs



Farmers receiving certificate of participation in training in KVK

After the successful training, inputs for demonstrations on coriander, fenugreek, fennel, ajwain and nigella were given to farmers in all three districts. A total of 84 demonstrations (FLDs) were conducted in these areas. Technological interventions in the FLDs given were, improved varieties, line sowing, seed treatment and other recommended POP.

Table 6.1 FLDs in tribal area during 2013-14 under TSP.

S. No.	Name of district	Number of demonstrations						Total
		Fennel	Cumin	Ajwain	Coriander	Fenugreek	Nigella	
1	Dungarpur	3	0	2	3	10	1	19
2	Banswara	3	0	2	3	20	1	29
3	Pratapgarh	3	5	2	5	20	1	36
4	Total	9	5	6	11	50	30	84

Three exposure trips of farmers of these districts to NRCSS, Ajmer were organized on 4<sup>th</sup> February, 2014 during Regional Krishi Vigyan Mela-2014 (Western Zone) at NRCSS, Ajmer. In all, there were 150 beneficiaries. During the exposure trip farmers were made aware about seed spices performance at NRCSS through visit of farm and experimental fields and technology exhibition arranged during the mela. Beside this, they were also enriched with the latest technical know how about scientific cultivation of seed spices by different speakers in Krishi Vigyan Mela-2014.



#### 6.4 National Seed Distribution Kisan Mela and Kisan Sangosthi

NRCSS has organized National Seed Distribution Kisan Mela and Kisan Sangosthi during 28-30 September 2013. The mela was inaugurated by Dr. O. P. Gill, Vice Chancellor, MPUAT, Udaipur. Dr. Balraj Singh, Director, NRCSS, presided the inaugural function of mela. Dr. Ram Gopal Sharma, Deputy Director (Agriculture), Ajmer and Sh. Rajesh Kumar, Principal, DAV College, Ajmer were guest of honour on this occasion. Dr. Balraj Singh briefed about the objective of organizing this event as to provide the technological knowhow and seeds of different seed spices and other rabi crops at a single platform. Chief Guest, Dr. O. P Gill emphasized on the integrated farming system approach including the crop production, animal husbandry, poultry, fishery etc. He urged the farmers to take advantage from these types of events organized by the institutes for farmers. About 1500 farmers from Rajasthan, Bihar, Maharashtra and Gujarat participated in the Mela and Sangosthi during three days. Different technologies were displayed by various ICAR Institutes, SAU's, state departments, private companies and NGO's through exhibition. During three days, different sessions were organized by the experts on conservation agriculture, production of vegetable, horticulture crop, drip fertigation, post-harvest and value addition, Farmer's rights etc. The quality seed of cumin, fenugreek, coriander, ajwain, fennel and other seed spices were also made available to the farmer's along with the *Trichoderma* culture for seed treatment.



#### 6.5 Western Zone Krishi Vigyan Mela-2014

Western Zone Krishi Vigyan Mela-2014 was organized during 4-7 February, 2014 at National Research Centre on Seed Spices, Ajmer (Rajasthan). This mega event was sponsored by Department of Agriculture and Cooperation, Ministry of Agriculture, GOI along with Indian Society of Seed Spices, Ajmer, Directorate of Areca nut and Spices Development, Calicut, National Horticulture Board, Gurgaon, Spices Board India, Cochin and United Phosphorus Limited, New Delhi were other sponsoring partners of this event. The mela was inaugurated by Chief Guest Dr. Gurbachhan Singh, Chairman, ASRB, New Delhi. Dr. S.M.K Naqvi, Director, CSWRI, Avikanagar, Sh. Ram Chandra Choudhary, Chairman, Ajmer Zila Dugdh Utpadak Sangh, Dr. Jitendra Singh Shaktawat, Deputy Director (ATMA), Ajmer were the Guests of Honour. In inaugural address, Dr. Balraj Singh, Director, NRCSS welcome the guests and farmers. Dr. Singh elucidated the purpose of organizing this mela event and appraised about the seed spice research carried out at NRCSS during last decade.

In the presidential speech, Chief Guest Dr. Gurbachhan Singh appreciated the efforts made by NRCSS for the benefit of the seed spices growers. He emphasized the production of quality seed spices for export demand. Shri Ram Chndra Choudhary advised them to grow the cash crops like seed

