वार्षिक प्रतिवेदन
Annual Report
2014-15

भा. कृ. अनु. प.
राष्ट्रीय बीजीय मसाला अनुसंधान केन्द्र
तबीजी, अजमेर – 305206 (राजस्थान) भारत

ICAR - National Research Centre on Seed Spices
Tabiji, Ajmer - 305206 (Rajasthan) INDIA

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(AN ISO 9001:2008 Certified Institute)

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Cover Photographs (From left to right)
Recent released varieties of NRCSS

- *Early maturing Ajwain variety AA 93*
- *Fenugreek variety AFg 4*
- *High yielding Nigella variety AN 26*
- *Stem gall resistant Coriander variety ACr 1*

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Contents

1. Preface

In the recent years climatic situations were harsh and unpredictable. Untimely winter rains during the rabi season in the past two years have caused severe damage in most of the seed spice crops. Cumin and coriander being the leading seed spices have faced huge loss due to biotic and abiotic factors both. In cumin, due to rains specifically during flowering and post flowering stage caused Alternaria blight incidence at high rate, whereas, hailstorms mashed the crops into pieces. In coriander, rains in the early growth stage created a high moisture levels in the heavy soils of eastern regions of Rajasthan i.e., the predominant coriander cultivating area called Haroti region, consisting of Kota, Baran, Bundi and Jhalawar favoring growth of protomyces fungus causing heavy incidence of stem gall. Seed spices are largely prone to both biotic and abiotic factors, therefore it is utmost important to deliver technology to sustain the upcoming challenges for sustainability of these crops.

ICAR-NRCSS is morally responsible for developing sustainable technologies for seed spices. Varieties are the most crucial technology for up scaling the productivity per unit area. It's a matter of great privilege and appreciation for the centre because during the present year from NRCSS, three varieties of seed spices have been identified and released for Rajasthan state viz., Fenugreek- AFg-3, Ajwain- AA-93 an early variety and Nigella-AN-20. Moreover, the NRCSS variety ACr-1 of coriander is found to be highly resistant against stem gall in more than 100 demonstration laid out for the last two years in the district of Kota, Baran, Jhalawar and adjoining areas of M.P, where the disease is occurring in severe form. The centre is dedicated to bring out better production, protection and post harvest technologies. The centre is also strengthening the seed production programme in large by adopting farmers participatory mode. The recent advances in seed spice research and development are part of the annual progress report presented, few technologies which are under pipe line mentioned in the report need to be highlighted for emphasizing the center's potential outcomes i.e., Ajmer Green coriander and Ajmer Fenugreek-3 leaf purpose varieties for harsh summer season of arid and semi arid area and numerous value added products of seed spices which ate under patenting process. During the reporting period the centre has spread its wings in the far eastern regions of the country and have also demonstrated technologies in the tribal area for entering into non-traditional areas. Events like farmers fairs, farmers training programme, FLD's etc have become an integral work for the centre. Besides a National Seminar on Hi-tech horticulture was also organized which was presided by dignified persons like DDG (HS)-ICAR, Padma shri (Dr) K.L. Chadha and Padma shri (Dr) Bharma Singh.

Annual progress report is a document reflecting the soul of an institute, I feel the present documents will definitely provide an insight for the existence of NRC on Seed Spices, Ajmer and its yearly progress in seed spice

research. The significant achievements of varietal development made by the centre during the period are worthy for applause, I congratulate the entire team for their sincere efforts. Making an effort in positive direction will definitely cater steps of success inform of small technologies which may add up and cast into a package for harnessing potential of a crop, with this I hope and wish that NRCSS will surely make them walk in path of seed spices betterment reaching global needs.

Balraj Singh

Ajmer

June 20, 2014

2. कार्यकारी सारांश

2.1 फसल सुधार

2.1.1 नवीन किस्में

- मेथी : अजमेर मेथी–4 (ए.एफ.जी.–4), जो कि एक उच्च उत्पादकता प्रदान करने वाली किस्म है, का विमोचन राजस्थान राज्य हेतु किया गया।
- अजवायन : अजमेर अजवायन–93 (ए.ए.–93) जो कि शीघ्र परिपक्वन गुणों से युक्त किस्म है, का विमोचन राजस्थान राज्य हेतु किया गया।
- कलौंजी : अजमेर कलौंजी–20 (ए.एन.–20) जो कि एक उच्च उत्पादकता प्रदान करने वाली किस्म है, का विमोचन राजस्थान राज्य हेतु किया गया।

2.1.2 पादप आनुवांशिक संसाधन प्रबंधन

- बीजीय मसालों के कुल 880 वंशक्रमों का मूल्यांकन किया गया जिसमें धनिया (585 वंशक्रम), सौंफ (72 वंशक्रम), अजवायन (96 वंशक्रम), सोवा (48 वंशक्रम), कलौंजी (43 वंशक्रम) एवं सेलेरी (36 वंशक्रम) को संपोषित किया गया है।
- बीजीय मसालों के 68 जननद्रव्य वंशक्रमों जिसमें जीरा (50 वंशक्रम) एवं एनाईस (18 वंशक्रम) सम्मिलित है, को संपोषित किया गया है।
- प्रमुख बीजीय मसालों के 180 वंशक्रमों का बहुस्थानीय मूल्यांकन किया गया, जिसमें धनिया (60 वंशक्रम), सौंफ (50 वंशक्रम), मेथी (50 वंशक्रम) एवं जीरा (20 वंशक्रम) सम्मिलित है।
- धनिया के कुल 585 जीन प्रकारों में विद्यमान परिवर्तनशीलता का प्रतिनिधित्व करने वाले धनिया के 156 जनन द्रव्यों का एक प्रमुख समूह बनाया गया।

2.1.3 प्रजनन कार्यक्रम

- तना सूजन रोग से ग्रसित धनिया की 9 जीव संख्याओं को रोग व्याप्त स्थानों से एकत्रित किया गया एवं इनकी अभिवृद्धि की गई।
- धनिया में लघु बीज आकार, अधिक आधार पत्तियों, मध्यम ऊंचाई एवं प्रति पादप अधिक पुष्प छत्र संख्या जैसे गुणधर्मों हेतु बनाये गये आनुवांशिक संग्रह को गुणवत्ता एवं उपज वृद्धि हेतु प्रोन्नतार्थ चयन किया गया।
- जीरे के जीन प्रकार सीई–4, सीई–7, सीई–8, सीई–13 एवं सीई–15 को उपज वृद्धि विशेषताओं के प्रति आशाजनक पाया गया। फ्युजेरियम उकठा रोग युक्त मृदा स्थान (सिक प्लाट) में परीक्षित जीरे के 40 वंशक्रमों में रोग के प्रति अभिक्रियाओं में बहुत अंतर देखा गया।
- मेथी के जीन प्रकारों ए3–47–1 (7.09 क्विं./हे.) एवं ए3–43–3 (7.0 क्विं./हे.) ने उत्कृष्ट मानक एएफजी–3 (5.92 क्विं./हे.) की तुलना में अधिक उपज प्रदान की।
- सीमित जल प्रतिबल अवस्थाओं में मेथी के जीन प्रकार सीआई–32–17, एएफजी–3, एएफजी–6, एएल–1–2 को आशाजनक परिणाम दायी पाया गया। जननद्रव्यों सीआई–32–17, एएफजी–3, एएम–293, बीजेड–19, एएफजी–4 को अधिकतम जल प्रतिबल अवस्था में अच्छा निष्पादन करते पाया गया। एएफजी–3 को सभी तरह के जल प्रतिबल अवस्थाओं में अच्छा निष्पादन करते पाया गया तथा जननद्रव्य सीएल–32–17 ने नियंत्रित एवं प्रतिबल अवस्थाओं में अच्छा निष्पादन किया।
- मानक किस्मों की तुलना में सौंफ की किस्मों यूएफ–206 (22–79 क्विं./हे.) एवं एएफ–12–एस–14 (20.16 क्विं./हे.) को आशाजनक पाया गया।
- वाष्पशील तेल, फीनोल, प्रति आक्सीकारक एवं कुल तेल की मात्रा जैसे गुणवत्ता के संदर्भ में हाल ही में विमोचित अजवायन की किस्म एए–93 को किस्म एए–2 के समान पाया गया।
- रा.बी.म.अ.के., अजमेर एवं एटीसी, कोटा इन दो स्थानों पर परीक्षण में कलौंजी की किस्म एए–20 से मानक किस्म पंत कृष्णा एवं आजाद कलौंजी की तुलना में उत्कृष्ट निष्पादन पाया गया।
- पीएयू, लुधियाना में किये गये परीक्षणों में सेलेरी की किस्म ए–सेल–5 (23.37 ग्राम/पौधा) एवं ए–सेल–8 (19.56 ग्राम/पौधा) का मानक की तुलना में आशाजनक अधिक प्रतिसाद देखा गया।
- एएनआई–7 के वंशावलियों से चयनित एनाईस की अग्रिम संख्याओं की अभिवृद्धि की गई।

- 69 सौंफ एवं 59 धनिया की किस्मों के आरएपीडी विश्लेषण में क्रमशः 16.22 प्रतिशत एवं 28.05 प्रतिशत बहुरूपता देखी गई।

2.2 फसल उत्पादन

2.2.1 खरपतवार प्रबंधन

- सौंफ एवं अजवायन में फसल–खरपतवार स्पर्धा की क्रांतिक अवस्था को क्रमशः 63 एवं 95 दिन पाया गया।
- खरपतवार प्रबंधन हेतु परीक्षित किये गये खरपतवार नाशकों में से आक्सीडाईसार्जिल (6 प्रतिशत ई.सी.) को सभी बीजीय मसाला फसलों हेतु प्रभावकारी पाया गया, जबकि पेंडामिथेलिन को मेथी एवं एनाईस के अतिरिक्त अन्य बीजीय मसाला फसलों में प्रभावकारी पाया गया।

2.2.2 अंतरशस्य फसल उत्पादन

- शुष्क फलोद्यान + बीजीय मसाला फसल अंतरशस्य फसल प्रणाली के अंतर्गत बेर + मेथी उत्पादनों में धनिया के समतुल्य अधिकतम उपज प्राप्त हुई तथा इसके पश्चात अधिकतम उपज बेर + कलौंजी उत्पादन प्रणाली में पाई गई, जबकि आवला आधारित प्रणाली में आंवला + अजवायन फसलोत्पादन के अंतर्गत अधिकतम धनिया समतुल्य उपज तथा इसके पश्चात आंवला + कलौंजी का क्रम आता है।
- सौंफ एव गाठगोभी (1:2) अंतरशस्य प्रणाली ने अधिकतम सौंफ समतुल्य उपज (1712 कि.ग्रा./हे.) प्रदर्शित की जिससे अधिकतम शुद्ध आय (रू. 1,26,000/हे.) तथा लाभ–लागत मान (2.65) प्राप्त हुआ, इसके पश्चात 2 : 2 अंतरशस्य प्रणाली का क्रम आता है।
- सोवा एव गाठगोभी (1 : 2) अंतरशस्य प्रणाली तथा सोवा एवं पत्ता गोभी (1 : 1) अंतरशस्य प्रणाली में अधिकतम सोवा समतुल्य उपज (1936 कि.ग्रा./हे.), शुद्ध लाभ (रू. 1,13,265/हे.) तथा लाभ लागत मान (2.72) 1 : 2 प्रणाली में प्राप्त हुई जो कि 1 : 1 अंतरशस्य प्रणाली के बराबर था।

2.2.3 बुआई विधि एवं उर्वरक उपयोग

- 75 से.मी. चौडे उठे हुए मृदा क्यारियों पर सौंफ, सोवा, अजवायन, एवं सेलेरी की युग्मित क्यारियों मे रोपाई के अंतर्गत अथवा बीज बुवाई विधि द्वारा 150 से.मी. चौडे एवं चार क्यारी पद्धति की तुलना मे अधिक उपज प्राप्त हुई। सौंफ की फसल में बीज बुवाई की तुलना में पौध रोपाई एवं मल्च पद्धति द्वारा अधिक उपज (1079.2 कि.ग्रा./हे.) प्राप्त की गई।
- छिड़काव, सूक्ष्म छिड़काव एवं सतही सिंचाई विधि से उगाई गई मेथी, धनिया, सौंफ, सेलेरी, एव कलौंजी की तुलना में बूंद–बूंद सिंचाई पद्धति द्वारा अधिक बीज उपज प्राप्त हुई।

2.2.4 मृदा कारकों का फसल वृद्धि पर प्रभाव

- धनिया एवं सौंफ की फसल पर क्षारीयता का प्रभाव था। आरएससी के स्तर में वृद्धि का पादप विकास एवं पोषक तत्वों के संग्रहण पर अधिक प्रभाव देखा गया।
- धनिया द्वारा पोषक तत्वों के संग्रहण पर मृदा तापमान का सीधा प्रभाव देखा गया, तापमान में गिरावट से नत्रजन की मात्रा में वृद्धि हुई, जबकि तापमान में कमी के कारण K एवं Cu की मात्रा में कमी पाई गई।
- मृदा संघनन स्तर में वृद्धि से धनिया के शाखा निर्माण एवं बीज उपज पर प्रभाव देखा गया।

2.2.5 ग्रीष्म / गैर मौसमी कृषि

- अजमेर हरी धनिया का हरी छाया जाली के नीचे ग्रीष्म काल में मानक किस्म एसीआर–1 एवं अन्य किस्मों की तुलना में सर्वोत्तम निष्पादन देखा गया तथा इसमें विलंबित पुष्पन भी देखा गया (55.75 दिन बुवाई पश्चात)। दो बार कटाई के द्वारा अधिक हरी पत्तियों का उत्पादन (2960.47 कि.ग्रा./हे) भी प्राप्त हुआ तथा इस पर सूर्णिल आसिता की घटनायें भी कम देखा गया (पीडीआई 8.33)।
- हरी छाया जाली के नीचे ग्रीष्म काल में मेथी की किस्म एएफजी–5 द्वारा मानक किस्म हिसार सोनाली एव अन्य की तुलना में उत्कृष्ट निष्पादन दर्शाया गया, इसमें विलंबित पुष्पन (35–75 दिन बुवाई पश्चात) तथा दो बार कटाई द्वारा अधिकतम पर्ण उपज (3633.02 कि.ग्रा./हे.) भी देखा गया। एएफजी–5 पर कीटों की संख्या भी न्यूनतम देखी गई।

2.2.6 अखाद्य नीम खली का उपयोग

- जौरे में 100 प्रतिशत आरडीएन के समतुल्य नीम खली के प्रयोग द्वारा निरपेक्ष नियंत्रण की तुलना में न्यूनतम उकठा की घटनायें देखी गई।
- धनिया मे 100 प्रतिशत आरडीएन के समतुल्य अरंडी की खली एव अरंडी की राख के प्रयोग द्वारा पर्णों की संख्या में वृद्धि, पौध ऊंचाई एवं शाखाओं की संख्या में वृद्धि दर्ज की गई।

2.2.7 शस्योत्तर प्रबंधन

- अनेक मूल्य संवर्धित उत्पाद जैसे सौंफ–आंवला शर्बत एवं

तैयार पेय, सौंफ–आंवला शर्बत तथा पेय, धनिया–आंवला शर्बत एवं तैयार पेय, बीजीय मसालों के जैविक पेय, सक्रिय खाद्य सौंफ–आंवला कैप्सूल, सौंफ पराग, सौंफ प्राश, मेहदिका चाय का विकास किया गया। ये सभी उत्पाद पैटेंट के लिये तैयार है एवं इस पर कार्य चल रहा है।

2.3 फसल सुरक्षा

2.3.1 सर्वेक्षण एवं निगरानी

- राजस्थान के मसाला उगाने वाले क्षेत्रों का पुष्पन एवं परिपक्वता काल के दौरान सर्वेक्षण किया गया तथा रोग ग्रसित पौधों के नमूनों को अध्ययनार्थ एकत्रित किया गया।
- राजस्थान में धनिया उत्पादक क्षेत्रों, विशेषतया कोटा, बारा एवं झालावाड जिलों में धनिया पर तना सूजन रोग की गंभीर समस्या दृष्टिगोचर हुई। रा.बी.म.अ.के. की धनिया की किस्म एसीआर–1 को बारा जिले के सभी प्रदर्शन स्थानों पर तना सूजन रोग से मुक्त पाया गया।
- जीरे के नमूनों में जड़ गॉठ एवं सूत्र कृमियों द्वारा क्षति की घटनाओं को दर्ज किया गया।
- सभी बीजीय मसाला फसलों में *एपिस फ्लोरिया* प्रजाति की मधुमक्खियों को प्रमुख परागणकर्ता के रूप में दर्ज किया गया।

2.3.2 रोग प्रबंधन

- गमलों में किये गये प्रयोगों में *ट्राईकोडरमा* के वियोजक सीयू–7–01 का प्रदर्शन *फ्यूजेरियम* मुरझान को कम करने में अधिक सूक्ष्म देखा गया तथा अन्य वियोजक सीयू–7–02, सीयू–03–01 और *टी.विरडी* को भी इसके समतुल्य पाया गया।
- मेथी में पर्ण झुलसा (दर्ज किया गया नया रोग) के कारक जीव पर अध्ययन को आगे बढ़ाया गया। लक्षणों, रोगात्मकता एवं आकारिकी अन्वेषणों के आधार पर पहचान कर यह निर्देशित किया गया कि यह रोगात्मक फफूंद *अल्टरनेरिया अल्टरनाटा* है।
- *अल्टरनेरिया अल्टरनाटा* के विरूद्ध प्रयोगशाला में कुशलता परीक्षण में पाया गया कि नीम तेल एवं लहसुन सत के प्रयोग द्वारा इसके विकास को काफी कम किया जा सकता है।

नाशी जीव प्रबंधन

- सौंफ का सोआ के साथ 2:1 परिणाम में अंतर शस्य विधि के द्वारा कृषि करने पर तर्तैया द्वारा उत्पन्न क्षति में काफी कमी देखी गई। इसी प्रकार वानस्पतिक औषधियों जैसे करंज अर्क 500 कि.ग्रा./हे. + करंज तेल 2 प्रतिशत के छिड़काव या कीटनाशक के प्रयोग जैसे क्लोथियानिडिन 50 प्रतिशत 1.0 कि.ग्रा/हे. सक्रिय तत्व की दर से 60 दिन बुवाई उपरान्त मृदा में उपयोग से भी तर्तैया पर प्रभावकारी नियंत्रण देखा गया। इसके अतिरिक्त इन सबके प्रयोग द्वारा फसल कटाई के उपरांत किसी भी प्रकार का कीटनाशक अवशेष फसल में प्राप्त नहीं हुआ।
- जीरे एवं अजवाईन की फसल में भण्डारण के दौरान डाईएटामीसियस अर्क का 8.2 प्रतिशत की दर से प्रयोग द्वारा सिगरेट भृंग (*एल.सेरीकॉर्ण*) द्वारा पहुँची क्षति को भी न्यूनतम स्तर पर पाया गया। अन्य अवलोकनों में अधिकतम भृंग मृत्यु तथा न्यूनतम बीज क्षति इसके प्रयोग से प्राप्त हुई
- जीरा एवं अजवायन के बीजों के इनके ही तेलों से (1.0 प्रतिशत वजन/आयतन) भण्डारण के पूर्व बंद डिब्बों में लेपन तथा भण्डारण करने से भृंगों द्वारा पहुंचने वाली क्षति से अधिकतम सुरक्षा प्रदान की जा सकती है।
- वानस्पतिक कीट नाशकों एवं जैव कीटनाशकों का धनिया पर माहू द्वारा कीये जा रहे क्षति के प्रति तुलनात्मक परीक्षण किया गया। कार्बनिक लवणों (78.05 प्रतिशत) के उपयोग से नाशी जीवों की संख्या में अधिकतम कमी देखी गई, इसके पश्चात करंज अर्क (76.13 प्रतिशत) तथा तुम्बा फल अर्क (75.40 प्रतिशत) का क्रम आता है।
- प्रक्षेत्र अवस्था में माहू के प्रति प्रतिरोधिता का धनिया की किस्मों के अध्ययन से ज्ञात होता है, कि राजस्थान धनिया–684 किस्म में न्यूनतम माहू संक्रमण (3.50/पुष्प छत्र) तथा इसके पश्चात के क्रम में एसीआर–1 एवं आरसीआर–41 में देखा गया (6.14/पुष्प छत्र)।
- धनिया फसल पर सम्पूर्ण फसल चक्र के दौरान कीटों की संख्या तथा प्रजाति का अवलोकन किया गया जिसमें 24 प्रकार के कीटों में से हिमनोप्टेरा (9 प्रजातियां), डिप्टेरा (6 प्रजातियां), हेमीप्टेरा (9 प्रजातियां), कोलियोप्टेरा (2 प्रजातियां), न्यूरोप्टेरा (1 प्रजाति) तथा लेपिडोप्टेरा (3 प्रजातियां) को देखा गया।
- सौंफ की फसल पर संपूर्ण फसल चक्र के दौरान कीटों की संख्या तथा प्रजातियों का अवलोकन किया गया, जिसमें 23 प्रकार के कीटों में हिमनोप्टेरा (6 प्रजातियां), डिप्टेरा (6 प्रजातियां), हेमीप्टेरा (3 प्रजातियां), कोलियोप्टेरा (3

प्रजातियां), न्युरोप्टेरा (1 प्रजाती) तथा लेपिडोप्टेरा (4 प्रजातियां) को देखा गया।

- धनिया की उपज पर परागणकर्ता के प्रभाव का आकलन किया गया, मधुमक्खियों के साथ पिंजरा बंद खण्डों में अधिकतम बीज उपज (1275.06 कि.ग्रा./हे.) प्राप्त हुई जबकि बिना मधुमक्खियों के पिंजरा बंद नियंत्रण में 565.69 कि.ग्रा./हे. की उपज प्राप्त हुई।
- सौंफ की उपज पर परागणकर्ता के प्रभाव का आकलन किया गया। मधुमक्खियों के साथ पिंजरा बंद खण्डों में अधिकतम बीज उपज (1592.63 कि.ग्रा/हे.) प्राप्त हुई जबकि बिना मधुमक्खियों के पिंजरा बंद नियंत्रण में केवल 268.25 कि.ग्रा/हे. की उपज प्राप्त हुई

2.4 मूल भूत विज्ञान

2.4.1 गुणवत्ता परिच्छेदिका

- धनिया के 15 जनन द्रव्यों एवं मेथी के 19 जननद्रव्यों में गुणवत्ता परिच्छेदिका एवं औषधीय गुणों का आकलन किया गया।
- मेथी में 4–हाइड्राक्सीआईसोल्यूसिन के आकलनार्थ एक त्वरित विधि का विकास किया गया।

2.4.2 रोग प्रतिरोधिता

- जीरे में फयूजेरियन मुरझान के विरूद्ध प्रति आक्सीकारकों अर्थात एस्कार्बिक अम्ल, सैलीसीलिक अम्ल, जेसमोनिक अम्ल तथा बैंजोईक अम्ल के प्रभाव का आँकलन किया गया। सभी परीक्षणों में इन अम्लों का रोग की घटनाओं में कमी पर नियंत्रण की तुलना में सार्थक प्रभाव देखा गया।
- जीरे की फसल पर एस्कार्बिक अम्ल, सेलीसीलिक अम्ल, जेसमोनिक अम्ल तथा बैंजोईक अम्ल जैसे प्रति आक्सीकारकों के प्रयोग का पादप बल बढ़वार तथा विकास पर वृद्धिकारक प्रभाव देखा गया।

2.4.3 बीज प्राईमिंग

- बीजों का हाईड्रोमेट्रिक्स प्राईमिंग के पश्चात निर्मित मृदा द्वारा मेट्रिक्स प्राईमिंग से नियंत्रण की तुलना में (8 दिन) 90 प्रतिशत बीजों में अंकुरण (4 दिन पहले) में शीघ्रता देखी गई।
- जीरे में प्राईमिंग अध्ययन के अंतर्गत देखा गया कि जीरे की किस्म जीसी–4 में आरजेड–209 की तुलना में अधिक प्रतिसाद था।
- जीरे के बीजों के क्रियात्मक अध्ययन द्वारा पता चलता है कि इसके बीज आवरण में उपलब्ध फलेवोनाईड की मात्रा इसके विलंबित अंकुरण का कारण प्रतीत होती है।
- जीरे का जेसमोनिक अम्ल (100पीपीएम), प्रोलिन (600.4 माइक्रोमोलर), बीएच (7 माइक्रोमोलर), एसए (7 माइक्रोमोलर), KH_2PO_4 (1 प्रतिशत) तथा पीईजी 8000 (20 प्रतिशत) के द्वारा बाह्य उपचार से नियंत्रण की तुलना में सार्थक उच्च उपज प्रदान करता है।

2.5 सामजिक विज्ञान

2.5.1 बीजीय मसाला आकड़ा कोष

- प्रमुख एपीएमसी/बीजीय मसाला मंडी के आँकड़ा आधार एवं आकड़ा संकलन हेतु प्रशासनिक प्रतिमान की रूपरेखा का विकास किया गया तथा बीजीय मसालों का गौण/अन्य स्त्रोतों की परियोजनाओं पर कार्य प्रगति पर है।
- भौगोलिक सूचना तंत्र के द्वारा भारत के बीजीय मसालों के एटलस का कार्य प्रगति पर है। पूर्वी राज्यों में पश्चिम बंगाल, उड़ीसा, आसाम एवं बिहार के आकड़ों का संग्रह कर लिया गया है।
- दस प्रमुख एवं गौण मसालों हेतु क्षेत्र, उत्पादन, उपज, मृदा रचना, मृदा गहराई, भारत की मंडियाँ, एईएसआर इत्यादि के विषय परक मानचित्रों की रचना पूर्ण कर ली गई है।
- उत्तर–पूर्व पर्वतीय क्षेत्रों में पासीघाट, अरूणाचल प्रदेश तथा गुवाहाटी, आसाम में दो कृषक प्रशिक्षणों का आयोजन किया गया।
- उत्तर पूर्व पर्वतीय क्षेत्र के अरूणाचल प्रदेश एवं आसाम राज्यों में बीजीय मसालों अर्थात धनिया, मेथी, अजवायन एवं कलौंजी पर किसानों के लिए 220 प्रदर्शन आयोजित किए गए।

2.6 बाह्य वित्त पोषित प्रकल्प

2.6.1 एनएमपीबी प्रकल्प

- सौंफ के 91 जननद्रव्य वंशावलियों में उद्धृत आवश्यक तेल का रासायनिक परिच्छेदिकरण किया गया। प्रतिशत आधार पर आवश्यक तेल की मात्रा जीएफ–2 तथा एफ–05–12 में 1.0 से 3.28 थी। सभी सौंफ जनन द्रव्यों में एनीथोल प्रचुर मात्रा में उपलब्ध था।
- धनिया के 141 जनन द्रव्यों से प्राप्त आवश्यक तेल का रासायनिक परिच्छेदिकरण किया गया, धनिया के 80

जननद्रव्यों से प्राप्त मिथेनोलिक उद्धरण का विश्लेषण कुल फिनोलिक एवं फ्लैवोनाईड की मात्रा के लिए किया गया।

- इस केन्द्र पर फसल अवशेष से आवश्यक तेल निष्कर्षण हेतु वाष्पीकृत आसवन की इकाई स्थापित की गई है तथा जीरे एवं अजवायन की बीजों तथा फसल अवशेषों से प्राप्त आवश्यक तेल का तुलनात्मक विश्लेषण भी किया गया है।

2.6.2 जीवीटी पोषित प्रकल्प

- अजमेर जिले से कुल 148 कृषकों का चयन जैव नियंत्रकों की प्रौद्योगिकी के प्रचार–प्रसार हेतु किया गया। जीरा, धनिया एवं सौंफ की फसलों में मुरझान तथा माहों के नियंत्रण हेतु जैव नियंत्रकों, *ट्राईकोडर्मा विरडी*, *वर्टिसीलियम लिकेनी* तथा नीम तेल का वितरण किया गया।

- उत्कृष्ट फसल प्रबंधन हेतु जैव नियंत्रकों के उत्पादन एवं उपयोग पर कृषकों के लिए प्रशिक्षण कार्यक्रम आयोजित किया गया।

3. Executive Summary

3.1 Crop improvement

3.1.1 New Varieties

- **Fenugreek**: Ajmer Fenugreek-4 (AFg-4), a high yielding variety released for Rajasthan State
- **Ajwain**: Ajmer Ajwain-93 (AA-93), a early maturing variety released for Rajasthan State
- **Nigella**: Ajmer Nigella-20 (AN-20), a high yielding variety released for Rajasthan State

3.1.2 Plant genetic resources management

- Evaluated total 880 lines of seed spices which includes coriander (585 lines), fennel (72 lines), ajwain (96 lines), dill (48 lines), nigella (43 lines) and celery (36 lines)
- Maintained 68 germplasm lines of seed spice crops which includes cumin (50 lines) and anise (18 lines)
- Multi-location trials conducted for 180 lines of major seed spice crops which includes coriander (60 lines), fennel (50 lines), fenugreek (50 lines) and cumin (20 lines)
- Prepared a core germplasm set of 156 coriander genotypes representing the total variability of 585 genotypes

3.1.3 Breeding programme

- Nine coriander populations selected from stem gall infected sites were advanced
- Advance selections were performed to enhance the quality and yield in the gene pools of coriander created for small seed size, high basal leaves, medium height and higher number of umbels per plant to enhance the quality and yield
- Cumin genotypes CE-4, CE-7, CE-8, CE-13 and CE-15 were found promising for most of the yield contributing traits. Forty cumin lines tested in *Fusarium* wilt sick plot showed presence of considerable variability for diseases reaction
- Fenugreek genotypes A3-47-1 (7.09 q/ha) and A3-43-3 (7.0 q/ha) performed better than best check AFg-3 (5.92 q/ha)
- Fenugreek genotypes *viz.*, CI-32-17, AFg-3, AFg-6, AL-1-2 were promising under limited water stress condition, genotypes *viz.*, CI-32-17, Afg-3, AM 293, BZ 19, Afg-4 performed well under complete water stress conditions. AFg-3 was suitable under all the water stress conditions provided while genotype CL-32-17 performed very well under control and stressed conditions
- Fennel genotypes UF-206 (22.79 q/ha) and AF-12-5-14 (20.16 q/ha) were found promising compared to check varieties
- AA-93, a new ajwain variety was found at par with AA-2 for quality estimates like essential oil, phenol, flavanoid, antioxidant content and total oil
- Nigella genotype AA-20 performed best compared to check varieties Pant Krishna and Azad Kalongi at two locations *i.e.*, NRCSS, Ajmer and ATC, Kota
- Celery genotypes A-Cel-5 (23.37 g/plant) and A-Cel-6 (19.56 g/plant) were found promising compared to check in a trial conducted at PAU, Ludhiana
- Anise early population selected from progenies of AAni-17 were advanced
- RAPD analysis of 69 fennel and 59 coriander genotypes showed 16.22 % and 28.05 % polymorphism respectively

3.2 Crop production

3.2.1 Weed management

- The critical crop-weed competition period in fennel and ajwain was found to be 63 and 95 days respectively
- Among nine weedicides tested, weed

management by oxadiargyl (6% EC) was most effective in all seed spices, whereas, pendimethalin acted well in all the seed spices except fenugreek and anise

3.2.2 Intercropping

- Under arid fruit orchard + Seed Spice intercropping sysetm, in Ber + Fenugreek gave highest coriander equivalent yield followed by Ber + Nigella, whereas, in Anola based system Anola + Ajwain resulted in highest coriander equivalent yield followed by Anola + Nigella
- Intercropping of 1:2 fennel with knolkhol in 1:2 intercropping ratio exhibited the highest fennel equivalent yield (1712 kg/ha), net return (Rs.1,26, 000/ha) and BCR (2.85) followed by 2:2 intercropping ratio
- Intercropping of 1:2 dill with knolkhol gave highest dill equivalent yield (1936 kg /ha), net return (Rs.1,13, 265 / ha) and BCR (2.72) it was at par with 1:1 ration of dill with cabbage

3.2.3 Sowing method and fertigation

- Under paired row transplanting or seed sowing method on 75 cm wider raised beds fennel, dill, ajwain, and celery gave higher yield than four row geometry on 150 cm raised beds. Fennel yield was recorded higher (1079.2 kg/ha) in transplanted crop with mulch compared to seed sown crop
- Drip fertigation showed higher seed yields in fenugreek, coriander, fennel, celery, nigella compared to crops raised under sprinkler, micro sprinkler and surface irrigation methods

3.2.4 Edaphic factors affecting crop growth

- Alkalinity influenced coriander and fennel crop growth
- Plant growth and nutrient uptake was significantly affected in coriander and fennel with increase in RSC levels
- Soil temperature significantly affected growth and nutrient uptake in coriander, Nitrogen content increased with decrease in temperature while K and Cu content decreased with decrease in temperature
- Higher soil compaction levels significantly affected branching and seed yield in coriander

3.2.5 Summer/offseason cultivation

- Summer season performance of coriander under green shade net showed Ajmer Green Coriander as best compared to check variety ACr-1 and others
- Ajmer Green Coriander showed late flowering (55.75 DAS) and higher yield (2960.47 kg/ha green leaves) with two cuttings, moreover it also showed minimum powdery mildew incidence (PDI: 8.33)
- Summer season performance of fenugreek under green shade net resulted AFg-5 as best entry compared to check variety Hisar Sonali and others
- AFg-5 showed late flowering (35.75 DAS) and highest yield (3633.02 kg/ha green leaves) with two cuttings, moreover minimum insect count was recorded on AFg-5

3.2.6 Non edible oil cakes application

- In cumin, neem cake application equivalent to 100 % RDN showed minimum wilt incidence compared to absolute control
- In coriander, castor cake with castor cake ash equivalent to 100 % RDN increased number of leaves, plant height and branching

3.2.7 Post harvest management

- Various value added products like fennel-aonla squash and RTS, dill-aonla squash and RTS, coriander-aonla squash and RTS, probiotic drink of seed spices, dill-aonla capsules as functional food, dill Parag, dill Prash, mehtica tea were developed, the same are under the process of patenting

3.3 Crop protection

3.3.1 Survey and surveillance

- Survey of seed spice growing areas of Rajasthan were done during flowering and maturity stages, diseased plant samples were collected for further studies
- Severe incidence of stem gall was observed in the coriander growing areas of Rajasthan specifically Kota, Baran and Jhalawar districts, NRCSS coriander variety ACr-1 was found to be free from stem gall in the demonstration trials in Baran district
- Root knot and lesion nematode population were recorded in cumin samples
- Honey bee *Apis florea was* recorded as most important pollinators of all seed spice crops

3.3.2 Disease management

- *Trichoderma* isolate Cu-7-01 showed maximum reduction in Fusarium wilt under pot conditions, Isolates Cu-7-02, Cu-3-01 and *T. viride* were at par
- Fenugreek leaf blight (a newly reported disease) causal organism was further studied; symptomatology, pathogenicity and morphological investigation confirmed the identity of pathogenic fungus as *Alternaria alternate*
- *In-vitro* bio efficacy test against *Alternaria alternata* showed maximum growth inhibition by application of Neem oil and garlic extract

Pest management

- Seed wasp damage reduced significantly in fennel by inter cropping fennel with dill in 2:1 ratio. Application of botanicals *i.e.*, Karanj meal 500 kg/ha. + Spray of Karanj oil 2% or insecticide *i.e.*, Clothianidin 50 % @1.0 kg /ha at 60 DAS as soil incorporation showed effective control of seed wasp in the crop, moreover no insecticidal residue was detected in seed after harvest
- Cigarette beetle (*L. serricorne)* damage was minimized during storage by application of diatomeous earth @ 0.2% in cumin and ajwain
- Further observation showed maximum beetle mortality and lowest seed damage by the application
- Impregnation of cumin and ajwain seed by own seed oil (1.0 w/v) before storage in close container gave maximum protection against beetle population
- Relative efficacy of botanicals and bio-pesticides against aphid on coriander was tested
- Maximum reduction in pest population was recorded for organic salt (78.05%) followed by ker extract (76.13%) and tumba fruit extract (75.40%).
- Varietal screening of coriander against aphid under field conditions showed Rajasthan Coriander-684 infested with minimum aphids (3.50/ Umbel) followed by ACr-1
- RCr-41 had the maximum aphid count (6.14/Umbel)
- In coriander insect population were observed throughout crop cycle
- Among 24 insect visitors there were Hymenoptera (9 species), Diptera (6 species), Hemiptera (3 species), Coleoptera (2 species), Neuroptera (1 species) and Lepidoptera (3 species)
- In fennel insect population were observed throughout life cycle
- Among 23 insect visitor there were Hymenoptera (6 species), Diptera (6 species), Hemiptera (3 species), Coleoptera (3 species), Neuroptera (1 species) and Lepidoptera (4 species)
- Impact of pollinators on coriander yield was assessed and highest seed yield (1275.06 kg/ha) was obtained in caged plots (with honeybee) whereas in control (caged without honeybee) it

was 565.69 kg/ha)

- Impact of pollinator on fennel was assessed, highest seed yield (1592.63 kg/ha) was obtained in caged plots (with honeybee) whereas, in control (caged without honeybee) it was only 268.25 kg/ha

3.4 Basic sciences

3.4.1 Quality Profiling

- Quality attributes and medicinal properties were assessed among 15 genotypes of coriander and 19 genotypes of fenugreek
- A rapid screening method for estimating 4-hydroxyisoleucine in fenugreek was developed

3.4.2 Diseases resistance

- In cumin against *Fusarium* wilt the effect of antioxidants *viz.*, ascorbic acid, salicylic acid, jasmonic acid and benzoic acid were assessed and all the treatment showed significant effect in reducing the disease incidence compared to control
- In cumin application of antioxidants *viz.*, ascorbic acid, salicylic acid, jasmonic acid and benzoic acid increased plant germination, vigour, growth and development

3.4.3 Seed Priming

- Hydro-matrix seed priming followed by matrix priming with synthetic soil proved best in hastening the germination by 4 days in 90 % seed compared to control (8 days)
- In cumin, priming studies showed that variety GC-4 is more responsive to priming than RZ-209
- Seed physiological studies of cumin indicated that flavonoid content in seed coat is mainly responsible for delay in seed germination
- In cumin, exogenous application of Jasmonic acid 100 ppm, Proline 600 µM, BH, 7µM, SA, 7 µM, KH2PO4 1%, PEG (8000) 20% gave significantly higher yield than control.

3.5 Social sciences

- Designed and developed the administrator modules for the database while data compilation on major APMC/seed spices mandi and scheme on seed spices from secondary/various sources is under progress
- Development of seed spices atlas of India using GIS approach is in progress, data compiled for Eastern state mainly West Bengal, Odisha, Assam and Bihar
- Prepared thematic map on area, production, productivity, soil texture, soil depth, Mandi in India, AESR etc for all the ten major and minor seed spice crops
- In NEH regions, two farmers training were organised at Pashigat, Arunachal Pradesh and Guwahati, Assam.
- In NEH regions 220 demonstrations on seed spices *viz.*, coriander, fenugreek, ajwain and nigella were given to farmer's of Arunachal Pradesh and Assam states

3.6 Externally funded projects

3.6.1 NMPB Project

- Chemo-profiling have been done for essential oil extracted from 91 fennel germplasm lines, essential oil content ranged on percent basis from 1.0 in GF-2 to 3.28 in AF-05-12-1. Anethole was found most abundant compound in all fennel genotypes
- Chemo-profiling have been done for essential oil extracted from 141 coriander genotypes
- Methanol seed extract of 80 coriander germplasm was also analyzed for total phenolic and flavonoid content
- A steam distillation unit for essential oil extraction from crop residues has been established at the centre, and a comparative analysis of essential oil obtained from seeds and crop residues of cumin and ajwain hase been done

3.6.2 DBT Project

- Total 148 farmers of Ajmer district were selected for dissemination of the technology on bio-control agents, distributed biocontrol agents *Trichoderma viride, Verticillium leconii* and Neem oil for control of wilt and aphids in cumin, coriander and fennel crops
- Orgainsed training programmes for farmers on production and application of biocontrol agents for better crop management

3.7 Other Activities

- Under MIDH programme 44 FLD's and three farmers trainings *i.e.*, two at NRCSS, Ajmer and one at KVK Barmer were conducted in Rajasthan state
- In NEH region 02 farmers training of 2 days were conducted, one in collaboration with CPRI-Region Station Shillong, Meghalaya and another with NRC on Orchids, Pakyong, Sikkim.
- In TSP regions of Rajasthan covering districts of Dungarpur, Banswara and Pratapgadh 109 FLD's of seed spice crops and two farmers training programme were conducted
- Organised two farmer fairs, one in Sep, 2014 dedicated for sale of seeds spices quality seed among farmers of improved cultivars and another in the month of feb, 2015 for demonstration of seed spice technology at NRCSS and also to make farmers aware about the recent progress
- During the reporting period more than 11000 farmers visited NRCSS

4. Introduction

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 flavor 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 for flavouring or seasoning agents to foods and beverages, and as herbal medicines.

India is known as the 'Land of Spices' and is the largest producer, consumer and exporter of spices and spice products. It produces a wide variety of spices like black pepper, cardamom (small and large), ginger, garlic, turmeric, chilli, coriander, cumin, fennel, fenugreek, dill, ajwain etc. 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 13.83 lakh ha (E) with production of 12.10 lakh tones (E) annually. In India, major area covered under different seed spices is 5.31 lakh ha in coriander, 5.93 lakh ha in cumin, 0.93 lakh ha in fenugreek, 0.99 lakh ha in fennel and 0.39 lakh ha in ajwain with their production in the country is 5.03, 3.94, 1.13, 1.43 and 0.26 lakh (E) tones respectively. The productivity of coriander, cumin, fenugreek, fennel and ajwain was 9.1, 6.2, 14.6, 17.1 and 8.6 q/ha respectively. The area and production of seed spices for the year of 2013-14 are present in Annexure II.

The prevailing world wide demand for seed spices is more than 200000 tones, of which India alone contributes 253525(E) tonnes annually (2013-14) valued at ₹ 2456.6 (E) crores. India is exporting only 10.80 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.

India commands leading position in world spices trade with 8, 17,250 tons of spices in volume and ₹ 13735.39 crore in value. The seed spices export from India has registered an all time high both in term of quantity (253525 tonnes) and value (₹ 2456.6 crores). The major market for different seed spices are USA, UAE, UK and South Africa.

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 IXth 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 and 0.15 to 0.23% organic carbon, available N 178.5 kg ha-1 (low), P_2O_5 12 kg ha^{-1} (medium), K_2O 85 kg/ha^{-1} (low), Ca 214.7 kg ha^{-1} (high), Mg 258 kg ha^{-1} (medium), S 27 kg ha^{-1} (medium).

The rainfall in the area is highly erratic and more than 90% of the rain is received during July to September with several intermittent long dry spells. The monsoon rains generally commence by the end of June but sometimes delayed till the first week of August. The rainfall is confined to the period mostly between July to September, the rainfall averages between 250-500 mm with a maximum of 750 mm in good rainy years and 50-200 mm in scanty rainy years. The temperature ranges from 2-5°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 and other weather parameters are given in Annexure I.

4.2 Mandate

- To conduct basic, strategic and applied research to 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:

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

4.3 Objectives

- Collection, evaluation, characterization and conservation of germplasm.
- Breeding variety with high yield potential, quality and resistance to biotic and abiotic stresses.
- Developing efficient agro-techniques for achieving the high production and productivity.
- Evolving better and efficient management system for control of pests and diseases.
- Study of nutritional and water management aspects.
- Development of package on organic farming of the seed spices for export, based on environment friendly

production and potential technology.

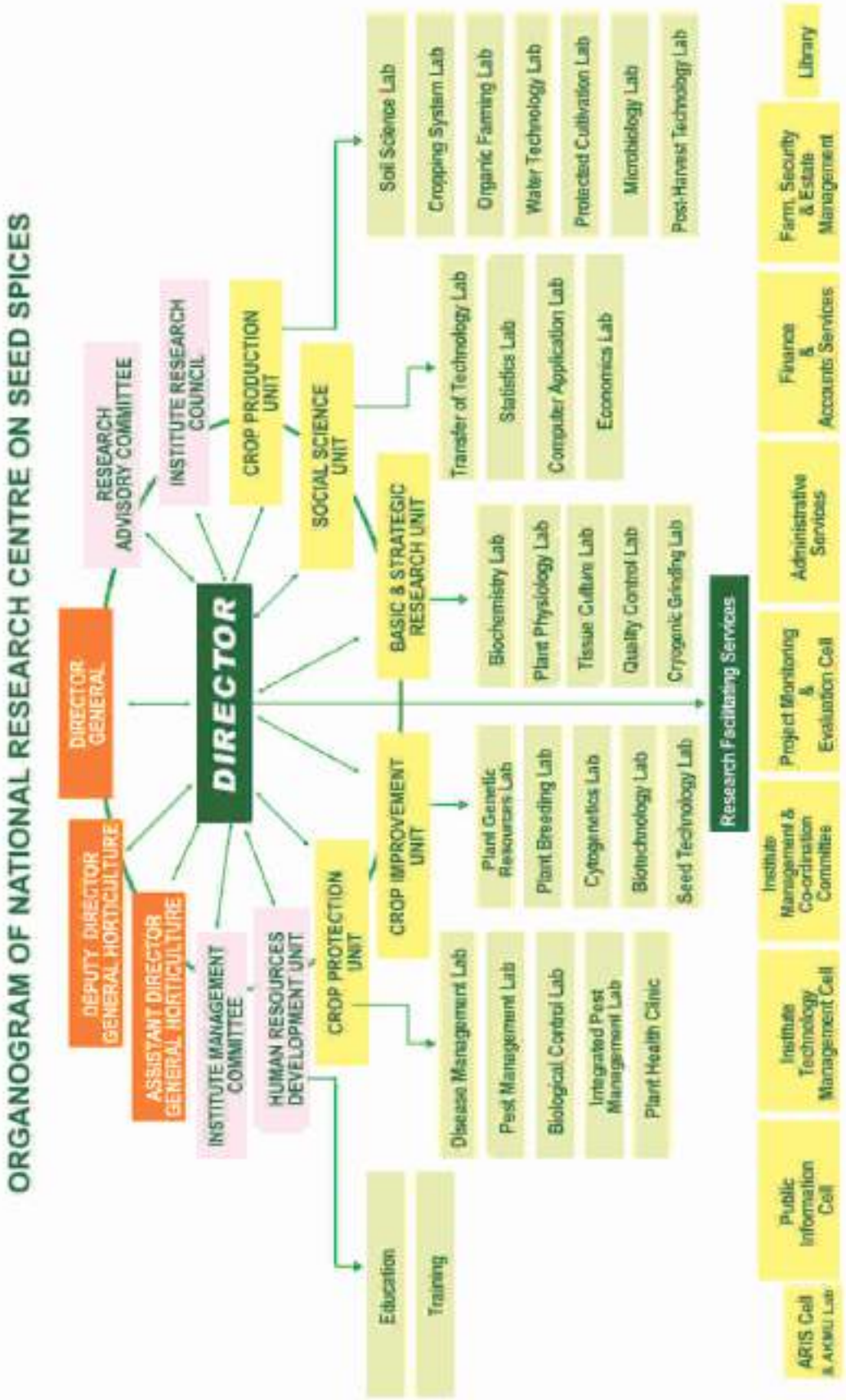
- Research on seed technology for production of quality seeds of improved varieties.
- Study of economics of production and marketing.
- Development of pre and post harvest technology for better processing, storage and utilization.
- Development of export oriented technology for export of raw and value-added products.
- Transfer of technology for farmers and extension agencies.

4.1 Staff position as on 31-3-2013

Grade	Sanctioned	Filled	Vacant
Scientific	20+1	22+1	-
Technical	8	7	1
Administration	11	7	4
Supporting	2	2	-
Total	**42**	**39**	**5**

4.2 Financial outlay (2014-15)

NRCSS, Ajmer	Plan 2014-15		Non-Plan 2014-15	
HEAD	**RE**	**Expenditure**	**RE**	**Expenditure**
Establishment Expenses	0.00	0.00	385.00	385.21
TA	3.00	3.01	8.00	8.00
Other charges including Equipment	0.00	0.00	4.00	3.96
Information Technology	5.00	5.04	0.00	0.00
Library Books & Journals	0.00	0.00	0.00	0.00
Works	0.00	0.00	0.00	0.00
HRD	8.00	7.99	0.50	0.50
Furniture & Fixture	0.00	0.00	4.00	3.92
Total Research & Operation expenses	75.00	74.96	45.00	44.77
Total Admn expenses	96.00	96.00	44.00	44.15
Guest House - Maintenance	0.00	0.00	0.00	0.00
Other Miscellaneoues	0.00	0.00	2.00	1.99
NEH	1.00	1.00	0.00	0.00
TSP	2.00	2.00	0.00	0.00
PENSION	0.00	0.00	13.06	13.06
Grand total	**190.00**	**190.00**	**505.56**	**505.56**


ORGANOGRAM OF NATIONAL RESEARCH CENTRE ON SEED SPICES
DIRECTOR GENERAL
DEPUTY DIRECTOR GENERAL HORTICULTURE
ASSISTANT DIRECTOR GENERAL HORTICULTURE
RESEARCH ADVISORY COMMITTEE
INSTITUTE RESEARCH COUNCIL
INSTITUTE MANAGEMENT COMMITTEE
HUMAN RESOURCES DEVELOPMENT UNIT
DIRECTOR
CROP PRODUCTION UNIT
SOCIAL SCIENCE UNIT
BASIC & STRATEGIC RESEARCH UNIT
CROP IMPROVEMENT UNIT
CROP PROTECTION UNIT
Soil Science Lab
Cropping System Lab
Organic Farming Lab
Water Technology Lab
Protected Cultivation Lab
Microbiology Lab
Post-Harvest Technology Lab
Transfer of Technology Lab
Statistics Lab
Computer Application Lab
Economics Lab
Biochemistry Lab
Plant Physiology Lab
Tissue Culture Lab
Quality Control Lab
Cryogenic Grinding Lab
Plant Genetic Resources Lab
Plant Breeding Lab
Cytogenetics Lab
Biotechnology Lab
Seed Technology Lab
Disease Management Lab
Pest Management Lab
Biological Control Lab
Integrated Pest Management Lab
Plant Health Clinic
Education
Training
Research Facilitating Services
Administrative Services
Finance & Accounts Services
Farm, Security & Estate Management
Library
Project Monitoring & Evaluation Cell
Institute Management & Co-ordination Committee
Institute Technology Management Cell
Public Information Cell
ARIS Cell

5. Research Achievements

Project 1(CI): Conservation, characterization and utilization of genetic resources in seed spices

CI-1: Management of plant genetic resources of seed spices crops (2014-19)

(R.K. Kakani, R.S. Meena, R. K. Solanki, S.S. Meena, Y. K. Sharma, S. Choudhary, A.K. Verma, Harisha C.B., Honappa Asangi and Diwakar Y.)

Collection and conservation of germplasm

ICAR-NRCSS is holding 2094 germplasm lines of ten seed spices crops. Crop wise total germplasm assemblage available at the center is given in table 5.1.

Table 5.1 Total germplasm assemblage at NRCSS

Crop	NRCSS Collection				NAGS Holding
	Indigenous	Exotic	Lost	Available	
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
Total	**759**	**83**	**128**	**714**	**2094**

Evaluation and maintenance of germplasm

All the crop curators maintained germplasm of respective crops as per requirement through sib-mating. The curators also evaluated the germplasm and recorded observations as per descriptors. In the reporting year following number of germplasm were sown in the field for maintenance and evaluation (Table 5.2).

Table 5.2 Number of seed spice germplasm lines maintained an evaluated during 2013-14

Crop	Number of germplasm	Crop	Number of germplasm
Coriander	585	Cumin *	50
Ajwain	96	Nigella	43
Fennel	72	Celery	36
Dill	48	Anise *	18

* Maintenance only

Multi location evaluation was also conducted for coriander (60 lines), fennel (50 lines), fenugreek (50 lines) and cumin (20 lines)

Coriander germplasm evaluation

Field view of coriander germplasm evaluation

Coriander germplasm set of 585 lines was evaluated in augmented block design (ABD) with 4 check varieties viz., Co-1, RCr-435, Hisar Sugandha and Hisar Anand. Among the germplasm set, only 567 entries germinated for which observations were recorded on 18 characters. The total variability recorded is summarized in table 5.3. Based on recorded date a core set representing the total variability

Table 5.3 Variability recorded in coriander

Characters	Min	Max	Average	CV (%)
Number of basal leaves	1.0	11	3.36	45.09
Length of longest basal leaf	2.5	43.4	13.04	57.3
Number of leaflets on longest basal leaf	1.0	5	3.88	17.49
Plant height up to main umbel (cm)	35.6	112.5	77.92	17.23
Plant height up to top (cm)	45.2	125.5	91.38	15.39
Primary branches	3.6	12	7.03	17.44
Secondary branches	11.3	33.4	20.23	17.12
Umbels / plant	15.5	84.2	50.6	21.27
Umbellates / umbel	3.0	8.6	5.69	13.96
Fruits / umbel	10.5	82.2	37.07	27.01
Yield / plant (g)	1.16	36.2	10.4	42.76
Streaks on stem	1.0	2.0	-	-
Stem pubescence	1.0	2.0	-	-
Stem colour	1.0	2.0	-	-
Flower colour	1.0	3.0	-	-
Arrang. of Umbellates in main umbel	1.0	2.0	-	-

was developed by making different classes for each character.

On the basis of categorized classes, manually 156 germplasm lines were selected to prepare the core set exhibiting

- Slightly lower mean than the population mean
- Almost same range as that of the population recorded
- Increased standard deviation than population mean
- Increased coefficient of variation (%) than population
- Representing most of the geographical regions

Fennel germplasm evaluation

Germplasm evaluation

Sixty five accessions were evaluated along with four checks *viz.*, AF-1, RF-101, RF-125 and GF-2 in a ABD. Wide range of variability was observed for all the characters studied. Seventeen promising accessions identified on the basis of yield were, AF-72 (7.4 q/h), AF-302 (6.6 q/h), AF-164 (6.5 q/h), AF-256 (6.1 q/h), AF-17 (5.3 q/h), AF-257 (4.6 q/h), AF-197 (4.3 q/h), AF-296 (4 q/h), AF-157 (3.8 q/h),AF-01-521 (3.3 q/h), AF-32 (3.3 q/h), AF-134 (3.2 q/h), AF-299 (3.2 q/h), AF-138 (2.8 q/h), AF-30 (2.5 q/h), AF-01-172-4 (2.5 q/h), AF-11 (2.5 q/h) as compared to checks AF-1 (2.4 q/h), RF-101 (1.45 q/h) and RF-143 (1.05 q/h).

Table 5.4 Variability recorded in fennel

Character	Min	Max	Average	CV (%)
Pri. branch/plant	4.2	10	6.8	19.63
Sec. branch/plant	5.8	24	12.6	31.39
Umbel/plant	8.0	123.2	42.8	47.01
Umbellate/umbel	18	46	27.4	19.99
Seed/umbellate	19	42.5	29.2	15.68
Plant height (cm)	90	210	154.3	14.66
Test weight (g)	3.8	9.4	6.8	22.2

Ajwain germplasm evaluation

Ninety six lines of ajwain were tested in ABD with four checks *viz.*, AA-1, AA-2, GA-1 and Lam selection. The variability recorded is given in table 5.5.

Table 5.5 Variability recorded in ajwain

Characters	Min	Max	Average	CV (%)
Days to germination	9	17	11.81	15.04
Plant height (cm)	74.2	148.8	105.05	13.03
Pri. branches/ plant	7.4	17	10.41	20.54
Sec. branches/ plant	131.8	327.6	229.08	20.48
Days to 50% flowering	60	147	94.19	10.61
Length of Ist internode at 50% flowering(cm)	0.46	2.92	1.20	37.83
Effective branches/ plant	141.6	314.2	228.42	17.51
Dia. of main umbel (cm)	4.14	6.9	5.34	10.17
Umbels /plant	141.6	314.2	226.87	16.77
Umbellates / umbel	7.8	19	12.77	19.69
Seeds /umbellate	14.2	26	18.62	8.35
Days taken to 75% maturity	125	173	161.94	3.26

Fenugreek germplasm evaluation (Multi location)

Fifty germplasm lines of fenugreek were tested in ABD with 5 checks *viz.*, Hisar Suvarna, Hisar Sonali, RMt-361, RMt-1 and AFg-3. The variability recorded in the tested lines is presented in table 5.6.

Table 5.6 Variability recorded in fenugreek germplasm lines

Characters	Min	Max	Mean	(GCV %)	(PCV %)
Days to 50 % flowering	48.88	70.28	54.97	5.366	5.691
Day of 75% maturity	132	136.20	133.96	0.000	1.114
Plant height (cm)	66.32	101.43	87.18	0.996	8.017
Pri. branches/plant	3.97	7.09	5.26	5.957	13.209
Sec. branches/plant	4.84	10.64	7.27	12.977	21.160
Pods on main stem	9.70	16.18	13.14	6.563	11.025
Pods per plant	25.66	64.50	52.24	14.216	15.229
Pod length (cm)	9.40	11.81	10.88	3.063	4.027
Shelling (%)	34.52	64.35	61.03	10.685	12.172
Seeds per pod	8.16	19.70	13.78	9.887	11.253
Test weight (g)	9.30	19.09	14.01	13.798	14.379
Yield per plant (g)	1.99	12.26	8.10	26.088	29.145

Celery Germplasm Evaluation

Thirty six germplasm lines were evaluated along with one check *i.e.*, A-Cel-1 in RBD of 3 X 2 m^2 plot size. Wide range of variability was recorded for all the characters studied. Out of 36 lines, 2 promising accessions Karnauli-16 (1.52 q/h) and Karnauli-4 (1.37) gave significantly higher yield than the check A-Cel-1 (1.29 q/h). Total variability recorded is given in table 5.7.

Table 5.7 Variability recorded in celery genotypes

Characters	Min.	Max.	Mean	CV %
Plant height (cm)	71	184	173.9	100.6
Umbel/ umbel	11	26	18.6	17.7
Seed/umbellate	8	28	19.6	19.5
Umbel/ plant	210	514	321.8	20.2
Primary branches	5	10	7.6	17.5
Secondary branches	9	28	13.6	26.3
Yield (g)	20.1	47.9	26.2	22.2

CI 20 Cytogenetical and biochemical characterization of cumin (2012-16)

(R. K. Solanki and S. S. Rathore)

Meiosis was found to be normal in genotype tested, 7 bivalents were observed suggesting the basic number n=7. No meiotic abnormalities were observed. Meiotic division in PMC occurred in the temperature range of 12-18° C. It was observed that the event of pachytene and diakinasis were fixed in very low frequency (out of 100 fields scanned only 5-10 showed these two events), in the cell cycle duration of these two events may be occurring very fast or may be less frequent as compared to other events which may be affecting total recombination frequency at the given time, further biochemical variation studied for enzyme activity was also found to be significantly variable in cumin genotype GC-4 and RZ-209.

Project 2 (CI): Genetic improvement of seed spices for improving productivity, quality and tolerance to biotic and abiotic stresses.

CI-4: Breeding for high yield, quality and resistance to biotic and abiotic stress in fennel (2009-15)

(R.S. Meena, R. K. Kakani, S. N. Saxena, R.S. Mehta, R.D. Meena, Krishna Kant and S. Choudhary)

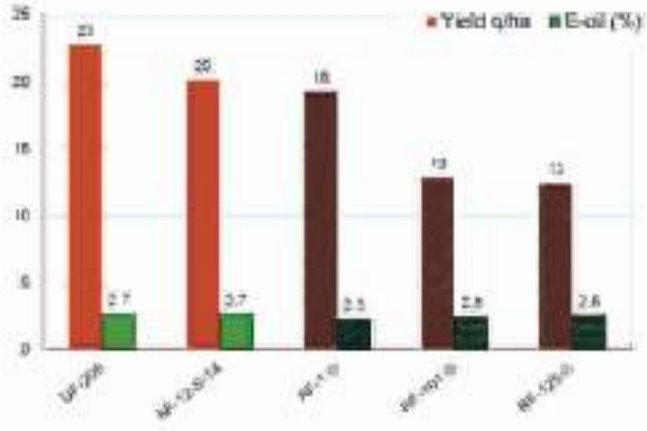
Initial evaluation trial of fennel

Fifteen genotypes were evaluated in RBD with three replication and three check varieties, analysis of variance revealed significant difference among the genotypes for all the traits including seed yield. Seed yield ranged from 9.23-22.79 q/ha, UF-206 (22.79 q/h) and AF-12-5-14 (20.16 q/h) were high yielders showing 18.08 % and 4.4 % higher yield than best check AF-1 (19.30 q/ha). The mean performance of fennel genotypes is given in table 5.8.

Table 5.8 Mean performance of fennel genotypes tested under IVT

Entries	Test weight (g)	Yield q/ha	Essential oil %
AF-05-12-1	4.36	11.04	3.28
AF-1	5.11	19.30	2.33
AF-12-S-14	4.41	20.16	2.70
AF-12-S-15	4.77	12.93	2.00
AF-12-S-29	3.86	18.16	3.27
AF-12-S-32	5.43	16.35	2.70
AF-12-S-34	4.59	14.05	2.53
AF-12-S-56	6.19	15.01	2.63
AF-12-S-59	5.70	13.53	2.67
AF-12-S-6	5.03	15.73	2.50
AF-F2-53	4.60	13.93	3.00
AJ-FNL-2	5.22	11.29	1.68
RF-101	5.27	12.90	2.50
RF-125	6.59	12.46	2.67
UF-131	5.05	14.53	2.67
UF-135	5.41	9.23	2.70
UF-168	6.10	14.68	2.17
UF-206	5.85	22.79	2.70
Mean	5.20	14.07	2.59
SD	0.69	2.49	0.38
CD	1.17	4.22	1.25

Fig 1 Seed yield (q/ha) and essential oil % in fennel genotypes



Dwarf fennel genotype maintained

Extra dwarf fennel plant identified earlier is being maintained through sib mating. However, seed setting was very less, sufficient seeds have been harvested from dwarf plants and attempts were made to cross with high yielding variety *i.e.*, AF-1. Hybrid seeds were very weak and shrunken which did not germinated on sowing. Efforts are going on for making successful recombinants.

CI-7: Breeding for high yield, quality and resistance to biotic and abiotic stress in celery (2009-15)

(R.S. Meena; R.K. Kakani, R.D. Meena, S. Choudhary and Krishna Kant)

Initial Evaluation Trial

A multi-location trial comprising of 11 genotypes was conducted at NRCSS, Ajmer and PAU Ludhiana during *rabi* 2013-14. Due to heavy hailstorm on 28 February 2014 at NRCSS was severely affected the crop and actual seed yield could not be harvested. At PAU Ludhiana trial was conducted successfully. Two genotypes, A-Cel-5 (23.37g) and A-Cel-6 (19.56g) were found best for yield as compared to checks. The genotypic performance for seed yield is given in the graph below

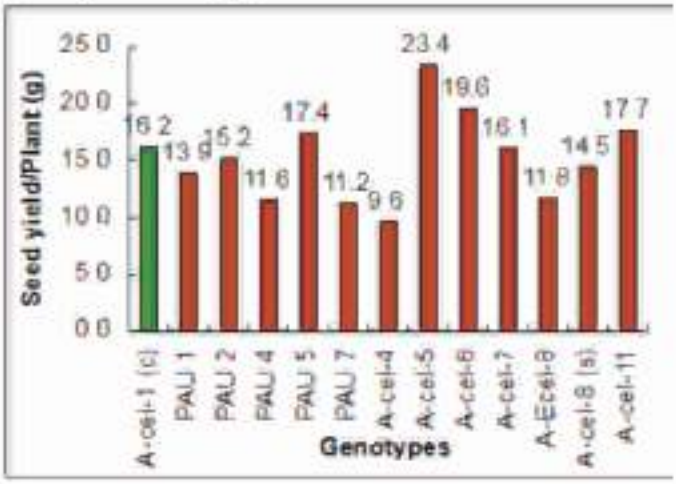


Fig 2 Seed yield recorded in celery during 2013-14

Some celery plants have been identified showing early maturity (32 days after transplanting) as compared to check ACel-1 (70 days after transplanting) and other celery accessions. Seeds were harvested and preserved for further experiments.

CI-8: Breeding for high yield and quality in dill (*Anethum graveolens* L and *Anethum sowa* Kurz.) (2009-15)

(R.K. Kakani, R.S. Meena and Y.K. Sharma)

One station trial was conducted with 12 test entries and two check varieties *viz.*, AD-1 and AD-2. The population AD-67 matured early as compared to other populations. The trial cannot be harvested successfully due to hail storm more than 80 percent loss was recorded.

CI-9: Breeding for high yield and improved quality in ajwain for *Rabi* and *Kharif* season (2008-2015)

(S.S. Meena, R.K. Kakani, R.S. Meena, R.D. Meena, K. Kant and R.S. Mehta)

Ninty six genotypes of ajwain were evaluated with four checks *viz.*, AA-1, AA-2, GA-1 and Lam Sel-2 in ABD. Maximum variability was recorded for seed yield/plant (55.75%) (Table 5.8). Quality profiling of ajwain variety AA-93 and AA-2 was also carried out (Table 5.9). The variability recorded is presented in table 5.9.

Table 5.9 Variability recorded in ajwain

Characters	Min.	Max.	Mean	CV (%)
Days to germination	9	17	11.81	15.04
Plant height (cm)	74.2	148.8	105.05	13.03
Primary branches/ plant	7.4	17	10.41	20.54
Secondary branches/plant	131.8	327.6	229.08	20.48
Days to 50% flowering	60	147	94.19	10.61
Umbels /plant	141.6	314.2	226.87	16.77
Umbellates / umbel	7.8	19	12.77	19.69
Seeds /umbellate	14.2	26	18.62	8.35
Seed yield /plant (g)	13	144	44.44	55.75

New ajwain variety released for Rajasthan State

Ajwain variety AA-93 was released for Rajasthan state in 30th meeting of State Seed Sub Committee on Agriculture and Horticulture Crops held on 8.01.2015.

The performance details of the variety are :

- Average seed yield 9.0 q/ha with normal crop geometry (40cm x 20cm)
- Matures in 123 days (40-45 days early than identified check varieties)
- Higher per day productivity *i.e.*, 10.83 kg/day in agronomic trial with changed geometry
- Gives 14.15 q /ha seed yield with 30 cm x 15 cm crop geometry
- Posses lodging resistance in case of heavy dew
- Can be easily identified by characters days to flowering and erect growth habit

Breeding for high yield and improved quality in nigella

(S.S. Meena, R.K. Kakani, R.S. Meena and K.Kant)

Two advance varietal trials were conducted at two locations *i.e.*, NRCSS, Ajmer and ATC, Kota to test 04 promising genotypes of nigella in comparision to 02 check varieties *viz.*, Pant Krishna and Azad Kalongi. Plant height, number of branches, days to 50 % flowering, other yield attributing traits and seed yield kg/ha were recorded. Genotype AN-20 gave the highest yield at both the locations 1000 kg/ha (Ajmer) and 1006 kg/ha (Kota). The other data of ancillary traits are given in table 5.10.

Table 5.10 Performance of nigella genotypes in trial (Ajmer)

Genotypes	Siliqua/ plant		Seeds/ siliqua		Yield (kg/ha)	
	Ajmer	Kota	Ajmer	Kota	Ajmer	Kota
AN-1	60.13	56.00	78.69	55.75	757	674
Azad Kalaunji (c)	56.12	52.00	79.52	61.25	790	823
Pant Krishna (c)	51.39	39.50	78.19	49.75	579	884
AN-21	53.12	58.00	78.92	60.50	595	831
KK Sel-10	66.46	50.75	81.12	52.50	676	666
AN-20	78.72	62.50	95.94	69.00	1000	1006
Sem±	2.07	1.74	2.76	1.91	24.34	8.28
CD at 5%	6.25	5.24	8.32	5.76	73.36	8.83
CV	6.80	6.54	6.72	6.57	6.65	6.67

New nigella variety released for Rajasthan State

Nigella variety AN-20 has been released for Rajasthan state in 30th meeting of State Seed Sub Committee on Agriculture and Horticulture Crops held on 8.01.2015.

The performance details of the variety are :

- 10.25 q/ha average seed yield (42-43% higher than Azad Kalongi and AN-1).
- At par with other varieties in total seed oil yield.

CI-15: Genetic enhancement of anise for yield and yield contributing traits (2011-16)

(R.K. Solanki and O.P. Aishwath)

Fifty early population developed by making selection in the genotype AA-17 were evaluated and advanced. Ten superior genotypes were evaluated for yield and other traits but the crop was damaged severely by hailstorm.

CI-18: Genomic study of seed spices (fennel and coriander) (2012-15)

(S. Choudhary and M.K. Vishal)

Diversity analysis of coriander and fennel varieties using molecular markers

RAPD analysis was done to know the molecular relationship among germplasm lines and released varieties of coriander (59 lines) and fennel (69 lines). OPB primer series was used, total 1553 RAPD bands were generated in 59 lines of coriander, 252 bands were polymorphic representing 16.22% polymorphism. Cluster analysis based on binary data using UPGMA method delineated the genotypes into two major groups. Genetic similarity matrix was calculated on the basis of Jaccards algorithm for RAPD data. Further characterization is in progress.

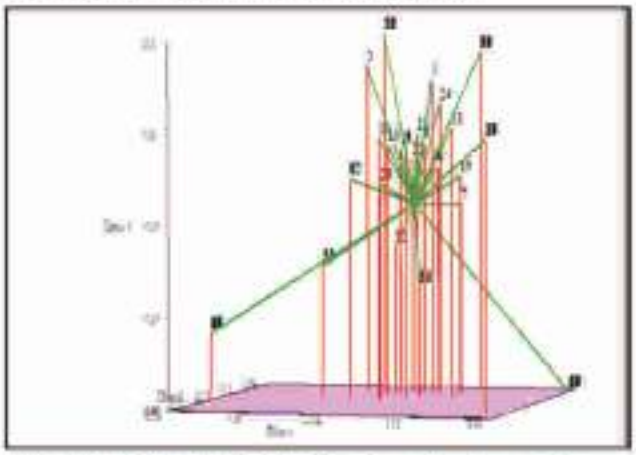


Fig 3 PCA analysis of RAPD data for coriander genotypes

In fennel, total 2062 bands were amplified of which 576 were polymorphic showing 28.05% polymorphism. 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. Further characterization is in progress.

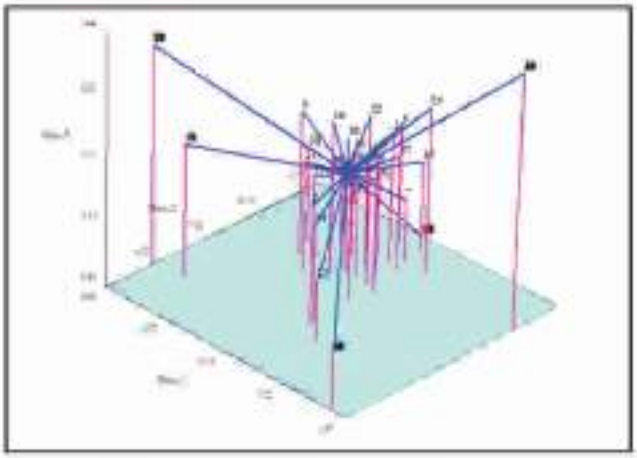


Fig 4 PCA analysis of RAPD data for fennel genotypes

CI-19: Enhancing genetic variability in cumin (2012-18)

(R.K.Solanki, R.S. Meena, Y.K. Sharma, R.K. Kakani, A. K. Verma and H.S. Mahla)

During the period 505 single plant selections were advanced, a station trial comprising of 10 genotypes and two checks (RZ-209 and GC-4) was conducted and, 40 entries were tested in wilt sick plot. Ample amount of variability was observed for growth behaviour, plant height, no of umbels, test weight. Variation was also high for plant architecture, plant height, biomass, number of umbels and test weight, whereas, variation for umbellets per umbel was found very low. Genotypes CE-13, CE-15, CE-7, CE-8 and CE-4 were promising. Unfortunately, due to severe hailstorm damage happened in cumin affecting the crop significantly.

Table 5.11 The range of variation observed in cumin lines

Trait	Minimum (Frequency)	Maximum (Frequency)
Plant height (cm)	20-25 (17)	Above 50 (02)
No of primary branches	4 (105)	8 (15)
No secondary branches	4-5 (31)	10-11 (12)
No of Umbels per plant	15-20 (14)	41-45 (1)
No of Umbellets per plant	Below 4 (16)	More than 6 (7)
Seeds per umbel	26-30 (192)	36-40 (6)
Test weight (g)	Below 2.0 g (53)	More than 4.6 g (4)
Seed yield per plant (g)	Below 1.5 g (234)	Above 4.5 g (2)

Field view of cumin germplasm evaluation trial

Spreading type cumin genotype with low biomass

CI/13.2.1: Breeding for high yield, powdery mildew resistance and suitability to limited moisture condition in fenugreek (2013-18)

(R.K. Kakani,S.N. Saxena, R.K. Solanki, Y.K. Sharma, S.S. Rathore and R. S. Mehta)

AFg-4: A new variety released for Rajasthan state

Two entries *viz.*, AFg-3 and AFg-4 were evaluated in coordinated varietal trial on fenugreek 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. Based on these coordinated trial one fenugreek variety AFg-4 was identified and released for Rajasthan state in 30th meeting of State Seed Sub Committee on Agriculture and Horticulture Crops held on 8.01.2015.

The performance details of the variety are :

- Seed yield (19.25 q/ha) was 12.53% higher as compared to national check Hisar Sonali in 11 trials conducted at different locations across the Rajasthan state
- AFg-4 gave 13.64 q/ha average seed yield which was 17.62 % higher than national check Hisar Sonali in coordinated trials.
- AFg-4 gave 26.38 q/ha seed yield with spacing 22.5 cm row spacing and fertigation of NPK 50,50,25 kg/ha
- AFg-4 is moderately resistant to powdery mildew and root rot.
- AFg-4 is also superior in quality as its seed contains 0.94 % 4-hydroxyisolucine (4HIL) which was 11.9 % higher than the national check Hisar Sonali (0.84%). Its seed also contains 1.74 % diosgenin which was 30.8 % higher than national check Hisar Sonali (1.33%). Seeds are also rich in crude fibre 21.7 % which was 11 per cent higher than Hisar Sonali (13.91%)
- AFg-4 gave 16.32 q/ha seed yield, which is higher than the check entries, thus having approx 16 % superiority over RMt-1 and RMt-305 in testing at Adaptive Trial Centre under Govt. of Rajasthan in Zone IIIa
- It can be easily identified through the characters listed in DUS testing

Evaluation of fenugreek genotypes under CVT

Two entries namely AFg-5 and AFg-6 were submitted for coordinated testing to AICRP on Spices. These entries are

selected on the basis of yield in station trial conducted at NRCSS, Ajmer. Eleven advanced lines developed through mutation breeding has been evaluated in randomized block design with three check varieties *viz.*, AFg-1, AFg-3 and Hisar Sonali using three replications, A3-47-1 was the highest yielder with 7.09 q/ha seed yield followed by A3-43-3 (7.0 q/ha) as compared to best check *i.e.* AFg-3 (5.92 q/ha). Performance was not good due to hail storm damage.

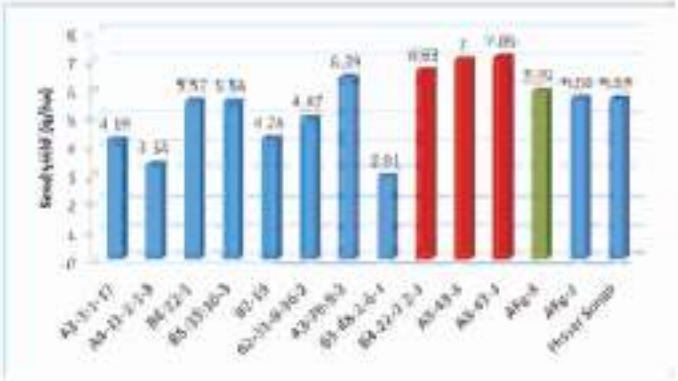


Fig 5 Performance of fenugreek genotypes for seed yield (q/ha) in trial

Evaluation of fenugreek genotypes in limited water environments

Thirteen selected fenugreek genotypes were sown in three different environment *viz.*, no water stress, water stress at mid term irrigation stage and water stress at terminal irrigation stage. All the genotypes showed significant interaction with environment. Water stress affected all the parameters studied. Stress given at midterm growth stage does not affect seed yield in most of the genotypes. Whereas terminal water stress affected seed yield significantly. Some genotypes were promising for limited water stress condition (CI-32-17, AFg 3, AFg 6, AL-1-2). Most of the genotypes were able to mitigate adverse effect of midterm water stress when crop was irrigated at terminal growth stage. Many genotypes performed substantially good under situation of complete water stress (CI-32-17, AFg 3, AM 293, BZ 19, AFg 4). AFg 3 (recently released variety) found suitable for all tested environments compared to other genotypes. CL-32-17 is another genotype which performed very well under both control as well as stressed conditions. Genotypes AM 413, RMt 305 exhibited lowest seed yield under various conditions.

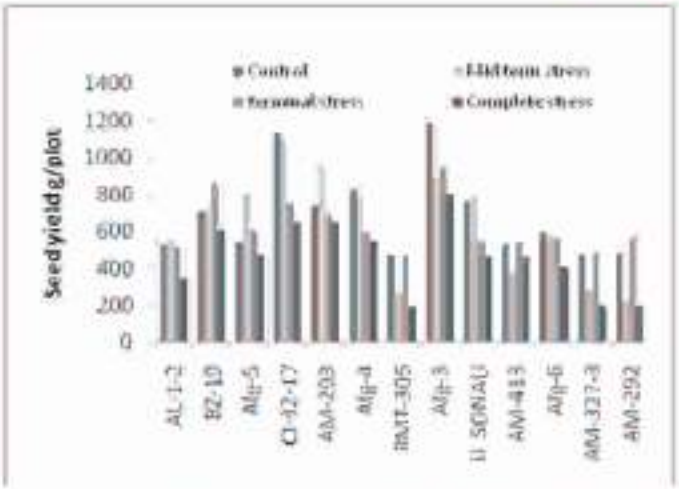


Fig 6 Seed yield of different fenugreek genotypes under various stresses and control conditions

CI/13.2.2: Breeding for high yield, small seed size and stem gall resistance in coriander (2013-18)

(R.K. Kakani, Y.K. Sharma, R.S. Meena and S.N. Saxena)

Evaluation of coriander populations

Nine coriander populations have been evaluated in randomized block design with 3 check varieties *viz.*, ACr-1, Hisar Sugandh and RCr-435. The trial cannot be harvested successfully due to hail storm damage which caused more than 80 per cent loss.

Gene pool (Composite) maintenance:

Three gene pools *viz.*, of early maturing and high yielding genotypes; of genotypes having small sized seed; of genotypes having 4 basal leaf, medium height, higher no. of seed per umbel and high yield; which were created through sib mating are being maintained. Selections were carried out within the pools for advancement.

Project 3 (CPd): Development and refinement of efficient crop production technologies of seed spices.

CPd-17: Identification of critical stage for weed management in seed spices (coriander, ajwain and fennel) (2010-15)

(R. Singh, G. Lal, R. S. Mehta, S. Choudhary and O. P. Aishwath)

Two field experiments involving fennel and ajwain were conducted at NRCSS, Ajmer. There were 18 treatments

comprising of initial weed free and weedy periods of 15, 30, 45, 60, 75, 90, 105, 120 days after sowing (DAS). The treatments were replicated three times in a randomized block design. Weed density and dry weight was recorded. Weed flora of the experimental field consisted of *Chenopodium murale* L., *Chenopodium album* L., *Cynodon dactylon* L. and *Cyperus rotundus*. Keeping the field weed free upto initial 15 days reduced the weed count as well as their dry weight significantly as compared to conditions allowing the weeds to come at 15 DAS and then removing. The magnitude of weed dry weight and weed count vary in different crops but the trend remained same in both the crops. The weed dry weight increased with the increase of weedy period from 15 DAS to harvest stage and it decreased with increase in weed free period from 15 DAS to harvest stage. Maximum seed yield of ajwain and fennel (638.15 and 1407.3 kg/ha) were recorded in weed free throughout growth period treatment, where as lowest were recorded (6.85 and 257.7 kg/ha) in weedy check. The critical stage for weed competition in ajwain and fennel were 63 and 95 days respectively (Fig 7). The loss in yield due to weeds (weedy throughout growth) in ajwain and fennel were 631.3 and 1149.6 kg/ha respectivly as compared with weed free plots. The loss in yield due to weeds (weedy upto 15 DAS to weedy throughout growth period) ranged 35.2-98.9 % in ajwain and 9.2-81.7 % in fennel as compared with weed free plots. There are negative returns due to very less yield of ajwain and fennel in weedy throughout growth period plots (Table 5.12).

Table 5.12 Seed yield and net returns of ajwain and fennel under different treatments of weedy and weed free period (DAS)

Treatment	Seed yield (kg/ha)		Net returns (₹/ha)	
	Ajwain	Fennel	Ajwain	Fennel
Weedy up to				
15 DAS	413.15	1,277.7	33200	24828
30 DAS	321.48	1,155.3	18267	18828
45 DAS	189.81	1,114.7	-2856	16995
60 DAS	140.74	927.7	-11063	8578
75 DAS	110.19	787.3	-15855	1761
90 DAS	87.96	663.0	-18873	-3839
105 DAS	39.63	601.7	-26415	-6589
120 DAS	13.63	544.7	-30523	-9672
135 DAS	-	448.3	-	-14005
150 DAS	-	383.3	-	-16922
Weedy	6.85	257.7	-24581	-13839
Weed free up to				
15 DAS	27.59	285.3	-23811	-17589
30 DAS	78.89	326.0	-16205	-15005
45 DAS	106.30	470.7	-12402	-9005
60 DAS	146.67	548.3	-6543	-6005
75 DAS	196.52	635.0	-311	-2589
90 DAS	256.11	661.0	9613	-1922
105 DAS	392.78	781.7	30566	2995
120 DAS	466.11	851.3	41381	5661
135 DAS	-	940.7	-	9161
150 DAS	-	1,088.7	-	15328
Weed free	638.15	1,407.3	66315	29161
CD at 5%	**33.3**	**284.4**		

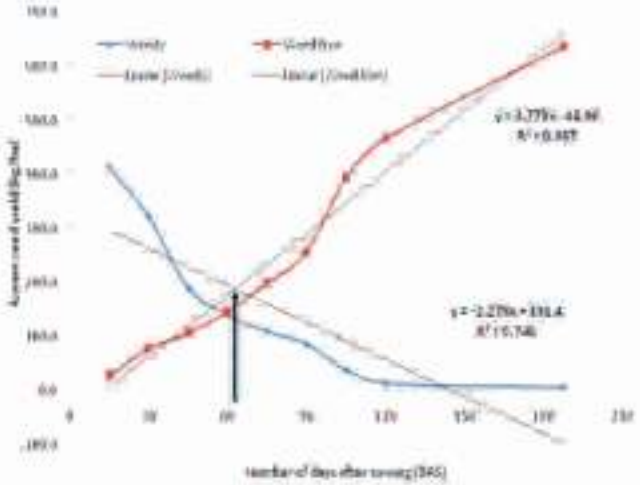


Fig 7 Critical stage (days after sowing) for weed competition in ajwain

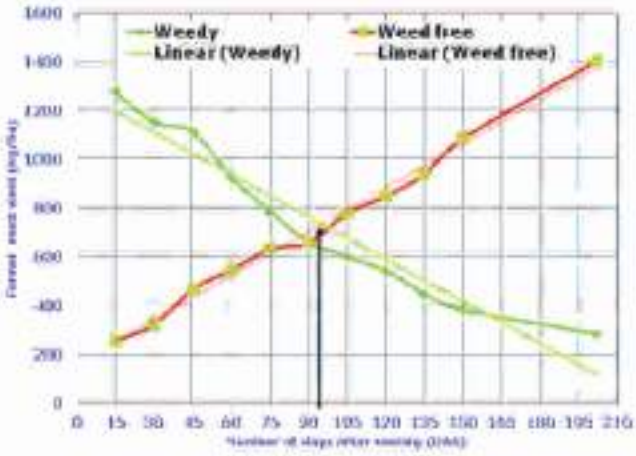


Fig 8 Critical stage (days after sowing) for weed competition in fennel

Evaluation of pre emergence or early post emergence herbicides for seed spices

An experiment was conducted using 9 herbicides (Pendimethalin, Oxadiargyl (6% EC), Isoproturon, Oxadiargyl (80%WP), Imazethapyr, Butachlor, Metribuzin, Oxyflourfen and Glyphosate) as pre emergence or early post emergence herbicides to evaluate their impact on weed control and crop growth of major and minor seed spices. The response of different herbicides was varying in different crops. Best herbicides were Oxadiargyl (6% EC) for all the seed spices followed by Pendimethalin in all the crops except fenugreek and anise.

CPd-18: Standardization of sustainable and profitable cropping system with fruit crops (2011-15)

(S.S. Meena, R.S. Mehta, G.Lal, O.P. Aishwath, R. Singh, K. Kant and R.D. Meena)

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 with aonla association. Fully grown ber orchard +fenugreek performed better resulting highest coriander equivalent yield (4318 kg/ha) followed by ber + nigella. Fully grown aonla orchard +ajwain resulted in highest coriander equivalent yield (8003 kg/ha) followed by aonla + nigella (7861.11 kg/ha). Fruit yield of ber and aonla was recorded higher with fenugreek. Due to hailstorm damage ber fruit yield and seed spices yield were very less than expectation (Table 5.13).

Ber & aonla orchard in kharif season

Table 5.13 Effect of seed spice based inter cropping with fruit trees

Treatments	Seed yield (kg/ha)	Straw yield (kg/ha)	Fruit yield (kg/ha)	Coriander equivalent yield (kg/ha)
Ber +Nigella	262.00	650.00	12017.00	4369.55
Ber +Anise	282.00	830.00	12013.00	4255.00
Ber +Rai	602.00	1454.00	11923.00	4241.89
Ber +Ajwain	306.00	950.00	11834.00	4284.67
Ber +Fenugreek	335.00	848.00	12510.00	4318.89
Ber + coriander	282.00	811.00	12027.00	4291.00
Aonla +Nigella	266.00	730.00	44950.00	7861.11
Aonla +Anise	288.00	821.00	43870.00	7567.67
Aonla +Rai	632.00	1500.00	43535.00	7536.72
Aonla + Ajwain	589.00	1550.00	44085.00	8003.61
Aonla +Fenugreek	644.00	1616.00	45062.00	7796.55
Aonla + Coriander	288.00	840.00	44030.00	7626.33
Sole Ber	-	-	12360.00	4120.00
Sole Aonla	-	-	45015.00	7502.50
Sole Nigella	445.00	1050.00	-	618.08
Sole Anise	655.00	1700.00	-	582.22
Sole Rai	2392.00	5554.00	-	1063.11
Sole Ajwain	628.00	1551.00	-	697.77
Sole Fenugreek	1601.00	3704.00	-	711.55
Sole Coriander	655.00	1652.00	-	655.00
Sem±	38.19	92.19	1053.38	270.24
CD at5%	109.75	264.97	3062.13	773.63
CV (%)	10.68	10.33	7.01	6.00

CPd-19: Screening of plant growth promoting rhizobacteria for coriander (*Coriandrum sativum* L.) (2011-15)

(B.K. Mishra, Y.K. Sharma, O.P. Aishwath, Krishna Kant and M. K. Vishal)

A Field experiment was conducted during *rabi* season of 2013-2014 to evaluate effect of selected rhizobacterial strains inoculants on growth and yield of coriander. A randomized block design experiment was laid out with 11 treatments and 3 replications on a plot size 4x3 m^2. These treatments included *Azotobacter, Pseudomonads* and PSB isolates from coriander rhizosphere. All the rhizobacterial isolates had positive effect on seedling vigour index compared to control (Fig 9). Highest seedling vigour index was recorded for T8 followed by T4 and minimum was found inT11 (control). These all rhizobacterial isolates accelerated the coriander seed germination. Effect of PGPR isolates on coriander plant biometrical data was recorded at 30, 60 and 90 DAS. At 30 DAS observations revealed that treatment T5, T8 and T9

increased the shoot length as well as root length. All the PGPR treatments induced early flowering than control. There was non-significant difference in root length, fresh root weight and dry root weight at 90 DAS of coriander plants. However, significant difference were recorded for fresh shoot weight and dry shoot weight at 90 DAS. There were significant effects of PGPR treatment on total NPK uptake by coriander plants as observed with analysis of harvested crop and plant biomass (Table 5.14).

Fig 9: Effect of PGPR treatment on coriander seedling vigour index

Table 5.14 Effect of PGPR on coriander plant biometrical data at 30DAS

Treatments	Shoot length (cm)	Root length (cm)	Fresh Shoot wt. (g)	Fresh Root wt. (g)	Dry Shoot Wt. (g)	Dry Root Wt. (g)
Azoto-4 (T1)	7.13	9.80	0.45	0.09	0.06	0.016
Azoto-5 (T2)	7.83	10.60	0.75	0.12	0.07	0.017
Azoto-7 (T3)	7.10	10.37	0.56	0.08	0.05	0.008
Azoto-8 (T4)	7.83	10.63	0.56	0.07	0.04	0.011
Azoto-9 (T5)	9.43	12.27	0.78	0.09	0.06	0.015
Azoto-10 (T6)	7.23	10.73	0.49	0.08	0.22	0.010
King's B-2 (T7)	7.23	10.33	0.51	0.09	0.08	0.020
King's B-9 (T8)	9.30	12.37	1.06	0.14	0.10	0.025
King's B-15 (T9)	8.43	10.83	0.57	0.09	0.05	0.010
PSB-15 (T10)	8.23	9.95	0.71	0.09	0.07	0.020
Control (T11)	7.43	9.60	0.49	0.08	0.07	0.014
SEm	0.41	0.55	0.38	0.02	0.05	0.003
CD (0.05)	1.71	1.62	NS	0.05	0.12	0.009

CPd-20: Isolation and evaluation of phosphate solubilising microorganisms for fennel (*Foeniculum vulgare* L.)(2011-15)

(B. K. Mishra, O.P. Aishwath and S.S. Rathore)

A field experiment was conducted to evaluate the effect of PSB isolates on growth and yield of fennel. Ten effective PSB isolates were used for seed bacterization using talc based formulation prepared at microbiology lab of NRCSS, Ajmer. Due to seed bacterization of fennel seeds with PSB, there was slightly early germination of all treatments in comparison to control. There were significant differences in plant biometrical character at 30 DAS. Similarly, at 60 DAS shoot length varied from 57.62 to 60.22 cm and highest shoot length as well as fresh shoot weight was recorded with T2. There was significant difference in fresh shoot weight, dry shoot weight and dry root weight at 90 DAS in comparison to control. PSB treated fennel plants showed slightly early 50 per cent flowering (116-118 DAS) as well as 75 per cent flowering (121-123 DAS) than the control. The highest seed yield was recorded with T10 which was at par with T5 and minimum seed yield was observed with control (5.15).

Table 5.15 Effect of PSB on Fennel plant biometrical data at harvest stage

Treatments	Plant height (cm)	Plant wt. (g)	Seeds yield /pl. (g)
T1	204.97	268.4	18.3
T2	201.2	219.5	13.68
T3	198.43	238.15	12.59
T4	200.1	246.8	11.53
T5	200.97	278	23.5
T6	202.3	298.03	16.22
T7	199.3	295.83	14.12
T8	199.17	229.87	15.67
T9	200.3	224.3	12.79
T10	200.3	264.47	25.26
Control	189.88	224.93	12.12
SEm	2.31	16.89	1.77
CD (0.05)	6.81	49.81	5.22

CPd-24: Fertigation scheduling for efficient nutrient and water management in major and minor seed spices (2012-15)

(R. Singh, B. Singh, G. Lal, R. S. Mehta, H. Asangi and S.P.Maheria)

Standardization of irrigation and planting/ sowing techniques for seed spices

An experiment comprising of two factors (bed size and planting method in fennel, dill, ajwain and celery) was conducted under drip fertigation. Two levels of factor A (75 and 150 cm wider raised beds) and 6 treatments of factor B (transplanting of fennel with and without mulch, direct seed sowing of fennel, dill, ajwain and celery) were conducted in factorial RBD with four replications. Two and

four number of crop rows were accommodated on raised bed (FIRB) having 35 and 90 cm upper width of the raised bed, respectively whereas spacing between two furrows were 75 and 150 cm in normal and wider beds, respectively. The results showed that paired row transplanting/sowing of fennel, dill, ajwain, and celery on 75 cm wider raised beds gave higher yield than transplanting/sowing of four row on 150 cm raised beds. The maximum yield (1079.2 kg/ha) of fennel were recorded under transplanted fennel with the mulch which was higher by 159.4 kg/ha than seed sown. The lowest yield was recorded in ajwain (259.2 kg/ha) directly sown by seed (Table 5.16). The seed yield of dill and celery were 919.8 and 1401.0 kg/ha.

Table 5.16 Seed yield of fennel, dill, ajwain and celery as influenced by bed size and sowing method under drip fertigation

Treatment	75 cm bed	150 cm bed	Mean
Fennel transplanted	1,120.9	970.8	1,045.8
Fennel transplanted with mulch	1,137.5	1,020.8	1,079.2
Fennel seed sown	1,027.1	900.0	963.5
Dill seed sown	743.8	1,095.8	919.8
Ajwain seed sown	268.8	249.6	259.2
Celery seed sown	1,495.8	1,306.3	1,401.0
Mean A	**965.6**	**923.9**	
Factors	**C.D.**	**SE(d)**	**SE(m)**
Factor(A)	NS	23.0	16.3
Factor(B)	81.5	39.9	28.2
Factor(A X B)	115.3	56.4	39.9

Transplanted fennel and seed sown fennel, dill, celery, ajwain on 150 cm raised bed

Transplanted fennel and seed sown fennel, dill, celery, ajwain on 75 cm raised bed

Effect of different nursery raising techniques and width of raised beds on growth and yield of transplanted fennel, ajwain, dill and celery

An experiment comprising of two width of raised bed (75 and 150 cm wide) with five sowing/planting methods (transplanted crop with mulch (TM), transplanted crop where nursery raised in soil, soil less media (SLM), pro-trays (PT) and direct seed sown (DS) in four seed spices (fennel, ajwain, dill and celery) were conducted in split plot design. The maximum yield of all the crops were recorded at transplanting with mulch followed by the nursery raised in portrays. In all the four crops, the lowest yield was recorded with the seed sown crop as compared with the transplanted crop. The maximum yield (1250.0 kg/ha) of fennel was recorded under transplanted fennel with mulch which was higher by 195.8 kg/ha than seed sown (Table 5.17).

Nursery raising method in of seed spices

Table 5.17 Effect of bed size, nursery raising technique on yield of seed spices (fennel, dill, ajwain and celery transplanted under drip fertigation

Treatment	75 cm bed				150 cm bed			
Nursery raising method/ crop	Fennel	Dill	Ajwain	Celery	Fennel	Dill	Ajwain	Celery
Nursery in soil	1,079.2	1,254.2	272.9	1,552.1	1,050.0	1,091.7	277.1	1,504.2
Nursery +mulch	1,250.0	1,320.9	377.1	1,614.6	1,075.0	1,212.5	358.3	1,593.8
Soilless media	1,108.3	1,091.7	264.6	1,525.0	895.8	1,045.8	239.6	1,291.7
Portrays	1,160.4	1,104.2	312.5	1,643.8	1,014.6	1,133.3	283.3	1,400.0
Seed sown	1,054.2	983.4	234.4	1,327.1	812.5	995.8	231.3	1,254.2
Factors	Factor (A)	Factor (B)	Interaction AXB	Factor (C)	Interaction AXC	Interaction BXC	Interaction AXB X C	
SE(m)	9.8	13.9	19.6	15.5	22.0	31.1	44.0	
C.D.	27.5	39.0	55.1	43.6	NS	NS	123.3	

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

An experiment having 4 irrigation methods (surface, drip, sprinkler and micro sprinkler irrigation) in main plot and 9 seed spice crops (Fenugreek, Nigella, Anise, Coriander, Ajwain, Celery, Dill, Fennel and Cumin) in sub plot with three replications was conducted at NRCSS. Among the irrigation methods, maximum average seed yield (492.6 kg/ha) was observed under drip fertigation followed by mini sprinkler (273.1 kg/ha), sprinkler (272.5 kg/ha) and lowest with surface irrigation (Table 5.19). Among the crops maximum yield was recorded in fenugreek (676.5 kg/ha) followed by fennel (597.8 kg/ha), celery and dill. Very less yield was observed for cumin, ajwain and anise. The crop was severely affected by hail storm hence poor yield was there in all the crops. The seed yield of fenugreek, coriander, fennel, celery, nigella were significantly higher with drip fertigation than other irrigation methods (Table 5.18).

Coriander and Nigella under drip irrigation

Fenugreek and cumin under drip irrigation

Table 5.18 Effect of different irrigation methods on yield of major and minor seed spices

Treatment	Irrigation method				
Seed spice crop	Surface irrigation (Flat bed)	Drip fertigation	Sprinkler irrigation	Mega-net irrigation (mini Sprinkler)	Mean B
Fenugreek	333.4	1516.7	360.0	495.9	676.5
Nigella	41.5	339.2	68.0	126.4	143.8
Anise	45.7	109.2	38.8	218.1	102.9
Coriander	242.8	518.4	263.3	436.1	365.2
Ajwain	69.4	92.5	71.8	240.3	118.5
Celery	464.5	652.5	501.7	385.3	501.0
Dill	411.2	418.3	473.3	173.6	369.1
Fennel	676.3	751.4	638.4	325.0	597.8
Cumin	65.0	35.5	37.0	57.0	48.6
Mean A	261.1	492 6	272 5	273 1	
Factors	C D	SE(d)	SE(m)		
Factor(A)	36.3	15.8	11.2		
Factor(B)	35.7	17.9	12.7		
Factor(B) at same level of A	73.3	35.9	33.6		
Factor(A) at same level of B	76.3	0.0	0.0		

Micro sprinkler in major and minor seed spices

CPd-25: Nutrient management for sustainable seed spices production (coriander and fennel) (2012-17):

(O.P. Aishwath, R. Singh, B.K. Mishra, R.S. Mehta, P. N. Dubey and Harisha C. B.)

Thresh hold level of N requirement of coriander (ACr 1) on soil test basis

Results revealed that plant height, no of branches, stover yield increased with higher doses of N, whereas seed yield and nutrient uptake were not conclusive due to crop loss by hail storm during the season. Growth parameters indicated that plant height can be achieved more than 5 feet and as many as about 30 branches, if coriander fertilized appropriately. Chlorophyll content and nutrient content was also enhanced with N inputs (Fig 10 & 11). However, carotenoids content decreased with increase in N, which is directly correlated to soil and plant N content. Availability of N, P and Fe improved with higher doses of N input (Fig. 2). However, Mn regains as its initial status at medium levels of N and exhausted at higher levels. Availability of Cu and Zn always remained lower to its initial status with all N levels.

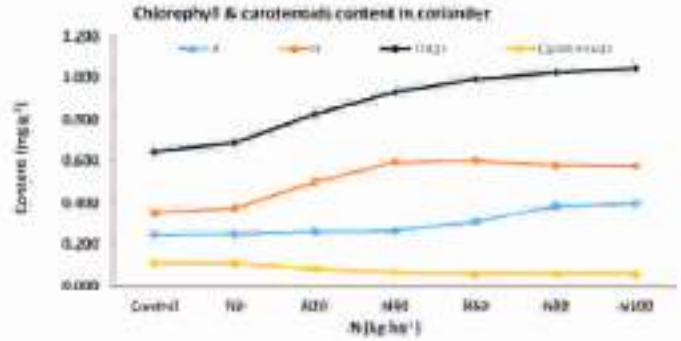


Fig 10. Effect of N levels on chlorophyll content in coriander leaves.

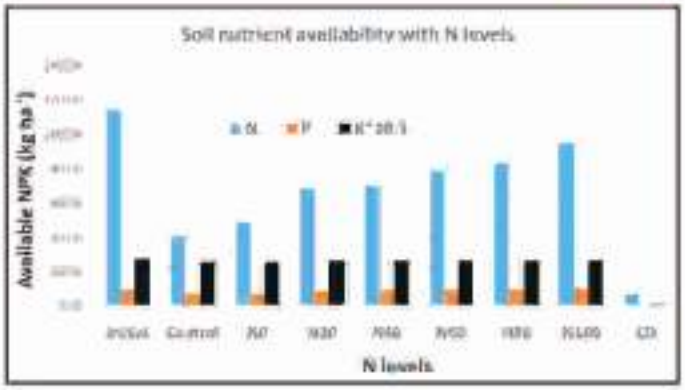


Fig 11. Effect of N levels on available macronutrients initial and after coriander crop

Thresh hold level of P requirement of coriander (ACr 1) on soil test basis

Results revealed that plant height, no. of branches, yield were more with applied P, whereas yield and nutrient uptake were not conclusive due to crop loss by hail storm. Leaf and root characteristics were followed the trend as that of previous year. Macro and micronutrient content were not influenced by P application. Soil available N drastically reduced and available P enhanced with applied P. However, available K remained unaffected. Available micronutrients were also not affected with application of P in coriander (Fig. 12).

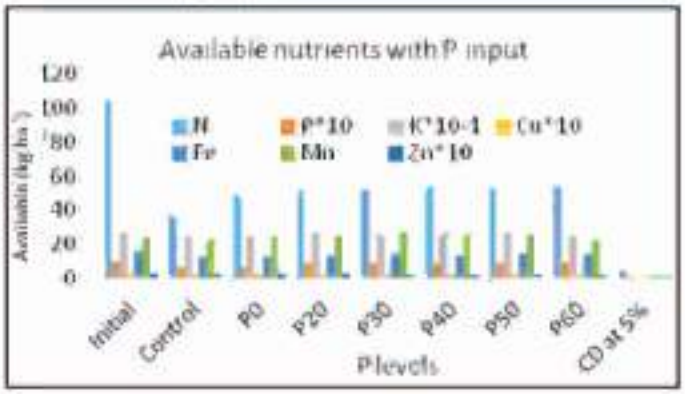


Fig 12. Effect of P levels on soil available nutrients before and after coriander crop

Response of coriander with integrated use of manures and fertilizers.

The present expriment was affected significantly by hailstorm, data on growth parmeters contributing to yield were recorded. The observed traits reflected a positive response of manures and fertilizers combined application (Fig 13).

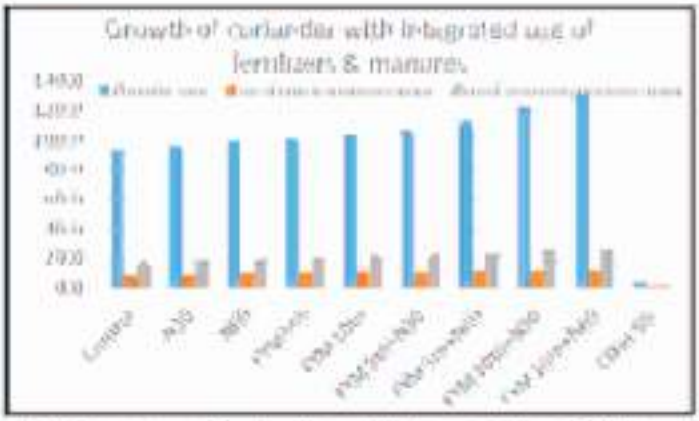


Fig 13 Response of coriander with integrated use of N, P and FYM

Response of coriander to potassium application

A pot experiment was carried out with 7 levels (0-80 kg K_2O ha^{-1}), there was no response of potassium observed as the soil contained sufficient amount of K (≈ 250 kg K ha^{-1}) for the crop.

CPd-26: Evaluation of seed spices for edaphic stress (coriander, cumin, fennel, fenugreek, anise, nigella and celery) (2012-17)

(O.P. Aishwath, R.S. Mehta, R.K. Yadav, R.L. Meena, B.K. Jha and P. N. Dubey)

Influence of alkalinity on coriander and fennel

Plant height and number of branches per plant decreased with increase in RSC levels drastically beyond 10 or 12 RSC. Seed and straw yield also decreased with higher levels of RSC (Fig. 14). P, K, Cu and Zn content decreased with increase in RSC levels. Nitrogen content was low at low RSC because of dilution effect, more at middle level and again lower down by hindrance in absorption at very high RSC levels. Fe content was also higher with higher levels of RSC. Nutrient uptake decreased with increase in RSC levels except for Fe (Fig 15).

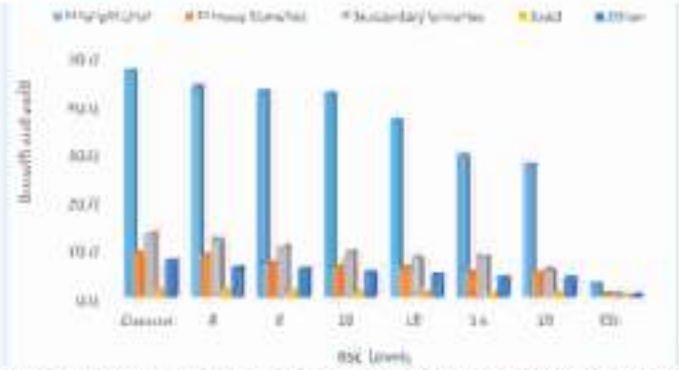


Fig 14. Influence of RSC water on growth and yield of coriander

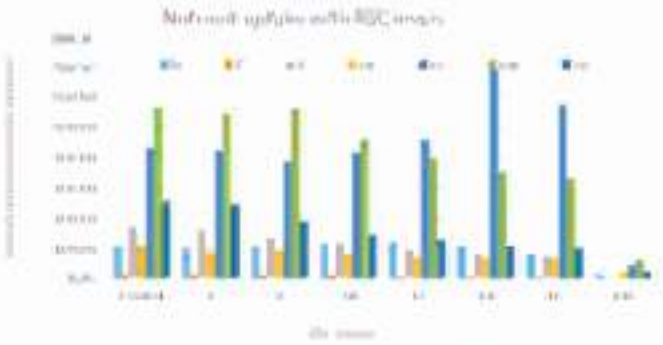


Fig 15. Influence of RSC water on nutrient uptake of coriander.

Performance of coriander with varying soil temperature regimes

Early germination was noticed at soil temperature between 26.76-29.96 °C and retarded at below and above temperatures. However, at the age of 62 DAS growth was more encouraging at the temperature 19.9-23.9 °C. At early stage, all the nutrients were more at temperature 29.96 – 32.17 °C. However, at later stage content was more at temperature 21.6-23.9 °C. Moreover, N content increased with decrease in temperature while K and Cu content decreased with decrease in temperature. This indicates that N will be the most limiting factor and K will be a least limiting factor if temperature rises by climate change (Fig 16).

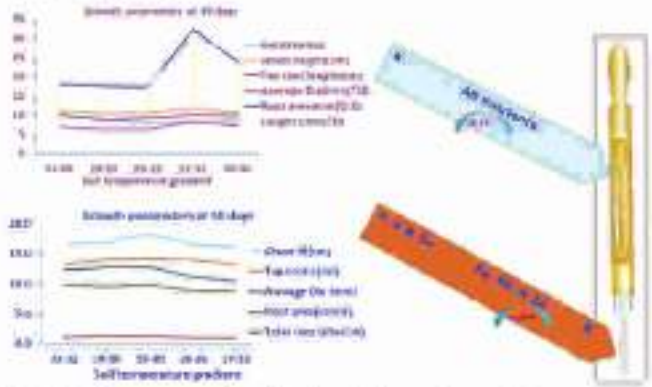


Fig 16 Performance of coriander with varying soil temperature regimes

CPd/13.6.1: Off Season production of coriander and fenugreek for green leaf (2014-17)

(G.Lal, R.S. Mehta, R. Singh, R.K. Kakani, S.S. Rathore, N.K. Meena, S.P. Maheria)

Performance of coriander lines for green leaf under summer season