वार्षिक प्रतिवेदन

Annual Report

2012-13

भाकृअनुप
ICAR

National Research Centre on Seed Spices

Tabiji, Ajmer-305 206 (Rajasthan) INDIA

NRCSS

वार्षिक प्रतिवेदन

Annual Report

2012-13

भाकृअनुप
ICAR

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
Phone : +91-145-2688401-2
Fax : +91-145-2684417
E-mail : nrcss.director@gmail.com
Web : www.nrcss.org.in

Chief Editor
Dr. S. N. Saxena (Principal Scientist)

Editors
Dr. Krishn Kant (Senior Scientist)
Dr. J.K. Ranjan (Senior Scientist)
Dr. R.S. Meena (Scientist)
Dr. R.K. Solanki (Scientist)
Dr. S. Choudhary (Scientist)

Hindi Translation
Dr. S.S. Rathore (Senior Scientist)

Photographs by
Sh. M.A. Khan (Technical Officer)
Sh. G.K. Tripathi (Technical Assistant)

Correct citation:
Annual Report 2012-13
National Research Centre on Seed Spices
Tabiji, Ajmer- 305206
Rajasthan, India

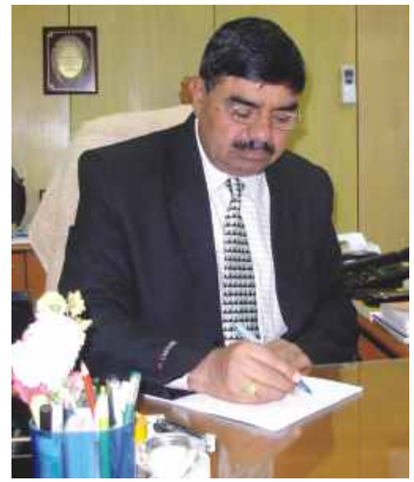
Printed at:
JOB Offset Printers, Ajmer
Ph. : 9829472031

Copies: 100

Contents

1. Preface
2. Executive Summary in Hindi
3. Executive Summary
4. Introduction
5. Research Achievements
   - 5.1 Crop Improvement
   - 5.2 Crop Production
   - 5.3 Crop Protection
   - 5.4 Basic Science
   - 5.5 Social Science
   - 5.6 Externally Funded Projects
6. Technology Assessed and Transfer
7. Education and Training
8. Awards and Recognitions
9. Linkages and Collaborations
10. Publications
11. RAC/IMC/IRC Meetings
12. Training/Refresher Course/ Summer / Winter Schools/ Seminars/Conferences/ Symposia/ Workshop Attended by the Scientists
13. Training/Refresher Course/ Summer / Winter Schools/ Seminars/Conferences/ Symposia/ Workshop Organized at the Centre
14. Distinguished Visitors
15. Empowerment of Women
16. Infrastructure development
17. Personnel
18. Other Information

1. Preface



It gives me immense pleasure while writing the preface. As soon as joined the National Research Centre on Seed spices as a Director sowing time of seed spices coincided. During the entire crop season I along with scientists of the centre observed and examined the performance of crops under field. I found a strong team of young and energetic scientists of different desciplines dedicated in seed spice research. With the concept of team work and collaboration we are trying to accelerate the momentum in research, teaching, training and extension activities to actualize the mandates of seed spice improvement.

During the year, regular research work of the centre was conducted smoothly and the ongoing experiments were restructured in sixteen programms. Apart from institutional projects two NAIP projects (Component II and IV), two DBT funded projects are also running at NRCSS. Since its establishment, the centre has made significant headway in research with respect to collection of indigenous and exotic germplasms. This year, the gene bank at NRCSS is augumented by adding both indigenous and exotic collections. Adding more to seed spices research, one fenugreek variety AFg 3 from NRCSS having more diosgenin content has been identified for national release in AICRP workshop. During the period under report, two advance lines, each of fenugreek, coriander and fennel from NRCSS gene bank have been included in the All India Coordinated Trials. One genotype of ajwain was identified for 35-40 days earliness in flowering than local and popular varieties.

I am happy to share that DUS guidelines for coriander and fenugreek have also been finalized by task force of PPV&FRA, New Delhi and adding more, DUS characterization of fennel and cumin will also be carried out in coming years.

Hi-tech intervention in production technology will make seed spice farming attractive to rural youth and arrest the migration from rural to urban areas by reducing drudgery in farm work through mechanization in all aspect of crop production and by making farming remunerative and profitable by developing greater productivity systems. It is the exact time when we should adopt precision agriculture in each component of crop production. Scaling up water productivity by applying irrigation through drip and conservation of moisture by mulching has been found better for realizing higher yield and water use efficiency. Fertigation technology will not only help to apply precise dose of nutrients but will also economize the fertilizer application, thus will improve and protect the soil health. Apart from this experiments on cropping system research, crop raising on different land configurations, weed and nutrient management, organic production technology, inter cropping of seed spices with vegetables and protected cultivation of seed spices were continued during the period.

Post harvest management and value addition is another area where NRCSS is doing experiments and has developed better drying and packaging methodologies for seed spices. Experiments on cryogenic grinding of seed spices under NAIP-IV project proved the worth of this technology for retention of volatiles and oleoresins and medicinal properties of seed spices as compared to conventional grinding. The centre is trying to popularize cryogenic grinding technology among seed spice stakeholders for its commercial exploitation.

Production of clean spices with export/import acceptability under the new WTO regime is one of the major focused area. Scientists of NRCSS are attentive and working on the newly emerging problems like yellowing and hyper red pigmentation in cumin, gummosis in fennel along with already existing problems of soil

borne diseases and sucking pests by performing experiments on biological control, biorational management, safe and judicious use of pesticides. Under NAIP-II project centre has developed organic production technology of fenugreek and coriander.

Exogenous application of PGRs for enhancing yield, seed priming and pelleting for reducing days to germination in cumin, quality profiling of seed spices germplsm are being carried out by the basic science division of NRCSS.

Special emphasis was paid to human resources development and capacity building among the scientists, students, extension workers and the farmers. Various programmes to implement this objective are documented in the report.

One national seminar on “Production, Productivity and Quality of Spices" was organized at Jaipur. Valuable recommendations have been made on crop improvement, crop production and protection technologies. Besides this National Kisan Mela and Kisan Sanghosthi, off- and on-campus farmers training were also organized. The scientists of NRCSS have been regularly invited to delivere radio, T.V. talks and write popular articles in news papers on seed spices for popularizing seed spice cultivation in newer areas.

The centre is now gaining recognition in other parts of India and abroad. Many famers, students and other stakeholders of seed spices from Rajasthan, Gujarat, Punjab, Haryana, U.P., Uttarakhand, M.P., Himachal Pradesh, Jharkhand and Maharashtra visited NRCSS under various training and visit programmes. To provide information on seed spices at a single plateform we have developed a “Seed Spices Knowledge Area” in which comprehensive information on seed spices is available and all the technologies developed at NRCSS are displayed through posters and live samples.

The centre will take lead role in refining the existing technologies to suit the local environmental and socio-economic condition. The socio-economic survey has been done in three districts of Rajasthan and GIS database has been developed for Rajasthan and Gujarat.

To fulfill the demand of pure seed material of seed spices, farmers' participatory seed production was started at NRCSS. This year, a total of 105 quintals of cumin and 10 quintals seeds of other seed spice was produced and made available to the seed spice growers.

Training manpower in various advanced technologies in seed spices crops by deputing them to various national and international organizations is required. During the period under report, two scientists of this centre visited USA for training in the area of marker assisted selection and sensor based applications.Three Senior Scientists were assessed by ASRB, New Delhi and promoted to Principal Scientist.

The financial management in this fiscal has been up to the mark with almost hundred per cent budget utilization. An important constraint faced by the centre is the inadequate farm area for research. With the increasing scientific strength and the expantion in the research projects the farm area is quite insufficient to take up the ambitious programmes being planned for the future. Efforts are on to acquire some additional area to enlarge the farm.

I am sure, the present momentum will carry on in coming days and NRCSS will continue to work for the welfare of seed spices growers and other stakeholders

Ajmer
April 15, 2013

(Balraj Singh)
Director

2- dk;Zdkjh lkjka'k

jk"Vªh; chtk; elkyk vuqla/kku dUnz u Hkkjrh; df"k vuqla/kku ifj"kn d lj{k.k e viu lLFkkiu d 13 o"k i.k dj fy; gA oreku e vuqla/kku ,o foLrkj xfrfof/k;k ikp vuHkkxk de'kZ Qly l/kkj] Qlykiknu] Qly lj{k.k] eyHkr foKku ,o lkekftd foKku d vUrxr lpkfyr dh tk jgh gA

2-1 vuqla/kku miyfC/k;k

2-1-1 Qly l/kkj

jk"Vªh; chtk; elkyk vuqla/kku dUnz d thu cd e 208 e[; rFkk 5 xk.k chtk; elkyk Qlyk d tuun0;k dk tkMk x;k ftUg feykdj dy tuun0; dh l[;k 2007 gk xbZ A bu tuun0;k e /kfu; d 133] thj d 68] lkQ d 54] eFkh d 208] vtok;u d 94] dyk th d 12] fMy d 14] vukbl d 18 ,o lyjh d 36 tuu n0;k dk eY;kdu lnfHkZr o"k 2011&12 e fd;k x;kA

mijkDr tuu n0;k d vykok vUrjk"Vªh; 'k"d {k= df"k vuqla/kku dUnz l ikIr 54 fon'kt tuun0;k dk eY;kdu Hkh fd;k x;kA gkykfd bu tuu n0;k e fofo/krk lkk;h x;h] ijUr i:ih Lrj ij] n'kt tuun0;k l fHkUu ugh ik; x;A

thj d 78 tuun0;k dk lLFkku d i{k= ij Eykfu jkx lfg".krk gr eY;kdu fd;k x;kA thddch&184] 1190] ,lh-b&6] ,o ,lh-b&7 tuun0;k u Eykfu jkx d ifr lgu'khyrk inf'kr dhA

,ukbl d tuu n0;k e ipj ek=k e fofHkUurk ik;h x;hA i"iu vof/k] ikni mpkb] f}rh;d 'kk[kkvk] N=dk dh l[;k ifrikni ,o ifjiDork vof/k e vf/kdre fofHkUurk ik;h x;hA tuu n0;k d ldy e ,uh&14],uh&15 ,o ,uh&16 e vf/kdre fofHkUurk ik;h x;hA

eFkh dh nk ifof"B;k ,,Qth&3 ,o 4 dk eY;kdu lefUor ifj;ktukrxr fd;k x;kA io fodflr mÙke itkfr fglkj lkukfydk dh ryuk e ,,Qth&3 ,o 4 itkfr 7-26 o 7-58 ifr'kr vf/kd mit d lkFk de'kZ f}rh; ,o rrh; LFkku ij ik;h x;hA nl mUur tuu n0;k dk fofHkUu x.kk d fy; eY;kdu fd;k x;kA nk o"kk d in'ku d vk/kkj ij ,e&317 tuu n0; u io fodflr mÙke itkfr ¼,,Qth&2½ l 12-89 ifr'kr l vf/kd mit nhA bl itkfr dk ,,Qth&5 d uke l lefUor ifj;ktuk e eY;kdu gr lfEefyr fd;k x;k gA

eFkh e ,e 4 ,o ,e 5 d 135 tuu n0;k dk ikni idkj] ikni mpkb] i.k idkj ,o vkdkj o of) 0;ogkj d vk/kkj ij p;fur fd;k x;kA o"k 2011&12 e vf/kd mit oky eFkh d LFkk;h mRijhofr;k dk ydj ,d {k=h; ijh{k.k yxk;k x;kA 3&28&93 mRijhorh e vf/kd mit ,o NkN;k jkx dk idki de ¼30 ihMhvkb½ ik;k x;kA bl o"k 2012&13 e e lefUor ifj;ktuk e ijh{k.k gr Hkt k x;k gA

/kfu; e 22 vfxe mUur itkfr;k dk ijh{k.k fd;k x;kA mÙke itkfr;k chMhoh@th,y&173 ,o ,e d ,l,e&1111 dk lefUor ifj;ktuk ijh{k.k e ,lhvkj&2 ,o ,lhvkj&3 d uke l if"kr fd;k x;kA

fMy dh dy 12 ifof"B;k e ,Mh&,l&01&03 ,o ,Mh&,l&01&24 u io e miyC/k mÙke itkfr l vf/kd mit nhA mit ,o i"iN=dk d y{k.kk d vk/kkj ij fodflr fMy d thu leg dk flc efVx fof/k }kjk vujf{kr fd;k x;kA

lyjh d 14 tuun0;k dk {k=h; ifj{k.k fd;k x;k bue l 4 tuun0; mÙke ik; x;A djko d rhu tuun0;k e vkih,&dkj&1 mÙke ik;k x;kA

vtok;u e ,d tuun0; tk fd vU; dh ryuk e 35&40 fnu io gh i"iu inf'kr dj jgk Fkk] fpfUgr fd;k x;kA

dyk th d 10 mUur tuun0;k e mit lC/kh x.kk e fofo/krk dk tkpk x;kA vf/kdre mit ,u&21 e ik;h x;hA

lkQ dh 13 ,o thj dh 6 itkfr;k e vkj,ihMh ikbej dh lgk;rk l fofHkUurkvk dk v/;;u fd;k x;kA bue vUrj itkfr fofHkUurk de'kZ 56-52 ,o 23-17 ifr'kr ik;h x;hA lkQ e 10 ,o thj e 6 thu dek dk ,ulhchvkb] ;,l,e Hkt k x;kA

2-1-2 Qly mRiknuk

chth; elkyk Qlyk ,o Qynkj Qlyk d Qly rU= e vkoy dk mi;kx vf/kd ykHkin ik;k x;kA chth; elkyk Qlyk e eFkh dk Qyh; ik/kk d lkFk vf/kdre ykHkin ik;k x;kA

lkQ e cUn&cUn flpkb i)fr dk i;kx fuEu nkc vFkok ipfyr fof/k;k d lkFk dju ij vf/kd mRiknu 'k) ykHk] ykHk ykxr vuikr ,o ty mi;kx {kerk vf/kdre ik; x;A

thj e 'kr ifr'kr ukbVktu] QkLQkjl dh vkifr oeh [kkn d :Ik e dju ij vf/kdre mit ikIr gbA

cht mipkj $ lMkekukl ¶y l enk mipkj $ uhe [kyh ½150 fdxk@gDV;j½ $ lYQj rRo dk i.k Qgkj l /kfu; e NkN;k jkx dk idki U;ure ik;k x;k tcfd thj e cht mipkj $ VkbdkMek fojhMh $ uhe [kyh @150fd-xk-@gDV;j rFkk x/kd rRo d i.k mipkj l mdBk jkx dk iHkko de ik;k x;kA lYQj rRo dk i.k Qgkj mipkj l thj l mdBk jkx U;ure ik;k x;kA

thj e U;ure >ylk jkx mipkfjr cht $ lMk¶y $ uhe[kyh @150 fdxk@ gDV;j $ l;kt d jl dk i.k fNMdko e ik;k x;k ijUr vf/kdre mit mipkfjr cht $ VkbdkMjek fojhMh uhe[kyh @150 fdxk@gDV;j $ djt ry dk i.k fNMdko½e ikb xbA

lkQ vk/kkfjr Qly rU= e lkQ dh vf/kdre mit gjk puk&lkQ&gjh [kkn Qly de e ik;h xb tcfd eFkh vk/kkfjr Qly rU= e vf/kdre mit exQyh&eFkh&gjh [kkn Qly de e ikb xbA thjk vk/kkfjr Qly r= e thj dh vf/kdre mit d fy; ckt jk&thjk ijfr lx enk lkjhdj.k 'kL; de mi;kxh ik;k x;kA lHkh 'kL; de e lokf/kd lkQ lerY; mit Xokj&thjk&gjh [kkn Qly de e ik;h xbA

lkQ dh vxrh cokb dju ij vf/kd mit ikIr gbA bll iky l Hkh cpko gvkA blh idkj /kfu;k] eFkh] vtokbu] dykth e e/;e vof/k e chtkb mRre ikb xbA vtej vtok;u&1 vtej vtok;u dh ryuk e mÿke ikb x;hA blh idkj vktkn dykth dh mit Hkh e/;e vof/k e cokb dju ij vf/kd mit ikIr gbA iÿkk xkHkh vkj eVj dh ryuk e xktj dh vUrjk'kL; [krh l lkQ] /kfu;k ,o vtok;u dh vf/kd mit ikIr gbA

thjk] /kfu;k ,o eFkh e Qly l [kjirokj dh ifrLi/kk de'k 51] 35 ,oe 31 fnu ij vR;kf/kd ikb xbA

thj e ijEijkxr ,o l{e Q0okjk i)fr dh vi{kk cn&cn flpkb i)fr e de'k 41-07 ,o 23-05 ifr'kr vf/kd mit ikIr gbA lkFk gh ty mRikndrk e Hkh c<krjh n[kh x;h tcfd dljh eFkh e ijEijkxr ,o cn&cn flpkb i)fr dh ryuk e l{e Q0okjk i)fr l flpkb dju ij mit e de'k 22-5 ,o 8-1 ifr'kr of) n[kh x;hA

dykth e vf/kdre mit ,o ty mRikndrk c<ku d fy; cn&cn flpkb i)fr }kjk flpkb ,o 20 ekbdku dh lykfLVd ijr }kjk Hkfe dk <du d fefJr i;kx l vPN ifj.kke ikIr g,A thj dh Qly e fuEunkc cn&cn flpkb i)fr vf/kd mi;kxh ik;h xbA

fofHkUu jf{kr ljpkukvk e l lykfLVd }kjk fufer pyu ;kX; ljxuek ljpuk /kfu; dh vf/kd mit yu gr vU; ljpukvk dh ryuk e lkFkd :Ik l vf/kd vPNh ik;h x;hA bl ljpuk e pik dhV dk idki Hkh U;ure ik;k x;k tcfd thj d fy; dhV jk/kh tky dh ljpuk e dky tky ,o [ky enku dh ryuk e vf/kdre mit ½806-78 fdxk@gDV;j½ ikIr gbA

ik"kd rRo vUrokg {kerk d vk/kkj ij thj dh fofHkUu itkfr;k fofHkUurk fy; g, FkhA N, P, K, Mn, Zn vkj Cu dh vUrokg nj GC-4 itkfr e pkyhlo fnu vf/kdre Fkh tcfd lkQ e itkfr vkj,Q&1 e ;g nj irkyhlo fnu vf/kdre ik;h x;hA eFkh dh itkfr jktUn dkfr e ,o UM-35 e ik"kd rRo vUrokg nj 30&40 fnuk e vf/kdre ik;h x;hA

/kfu; e IW:CPE vuikr 0-6 jgu ij N P K ,o Zn dk vf/kdre fu"d"k.k ik;k x;k tcfd lkQ e ;g vuikr 0-8 mi;Dr FkkA eFkh }kjk N P K vkj l{e rRok dk fu"d"k.k IW:CPE vuikr d mÿkjkÿkj c<u ij c<rk gvk ik;k x;kA /kfu; dh Qly enk vEyrk d ifr lfg".k ik;h x;h tcfd eFkh dh mit vEyh; enk e de gkuk n[kk x;kA

jktLFkku d fofHkUu ftyk ;Fkk vtej] ckjk] >kykokM vkj dkVk d /kfu;k [krk e l 25 enk ueu ,df=r fd; x;A bldk mnn'; jkbtkLQkfjd thok.kvk dk iFkd djuk FkkA bu ueuk e l iFkd fd; x; 36 lo/ku e l 16 lo/ku mUur ik; x;A

fofHkUu chtk dk l[kku dh fof/k;k e lkj 'k"d ;U= fof/k lkQ d fy, mRre ikb xbA ,Y;fefu;e vk/kkfjr Fkfy;k vU; Fkyh;k dh vi{kk lkQ ,o thj d HkMkj.k e mRre ikb xbA

2-1-3 ikni lj{k.k

lo{k.k l ikIr vkdMk d vk/kkj ij chth; elkyk mRiknd {k=k e thj e mdVk] >ylk ,o NkN;k jkx] /kfu; e NkN;k] >ylk jkx] lkQ e NkN;k ,o rylhrk jkx ,o eFkh e NkN;k ,o rylhrk jkx dk idki e/;e l vf/kd ik;k x;kA

thj e ihykiu ,o lkQ e xeklhl dk fodkj mHkjrh gb leL;k ikb xbA foyk;rh lkQ e QkbykMh ,o i.k /kCc dk iFke nf"Vrk irk yxkA ¶;tjh;e d 12 LFkkuh; idkj ,o vYVjuVh;k d 6 idkjk dk mud vkdkfjdh ,o chtk.k e fofHkUurk d vk/kkj ij yk{kf.kdr fd;k x;kA lLFkku d i{k= e lo{k.k dju ij ik;k x;k fd NkN;k jkx dykth dk NkM dj ckdh lHkh Qlyk e FkkA vU; egRoi.k chekfj;k e fMy e tM xyu ,o >ylk jkx] dykth e tM xyu] i.k/kCck jkx ,o foyk;rh lkQ e QkbykMh e/; l vf/kd ik; x;A thj dk mdBk jkx Qly dh vkjfHkd voLFkk e tcfd >ylk jkx tuojh ekg e i"iu voLFkk d le; vf/kd ik;k x;kA eFkh] /kfu;k ,o thj e NkN;k jkx ,o rkieku e /kukRed lglc/k ik;k x;kA

Tkhj e mdBk] >ylk rFkk NkN;k jkx ,o pik dhV d iHkkoh fu;=.k gr dod ,o dhVuk'kh d fNMdko d pkj fofHkUu i;kx e l lph&2 lokre ikb x;hftle Vcdkuk tky l chtkipkj ,o eUdktc ,o ikfidkuk tky dk odfYid fNMdko lkFk gh ,lhVkfefiM] bfeMkDykjfiM ,o djkFkhu dk fNMdko Hkh lfEefyr dju ij chekfj;k ,o dhVk d idki dk lkFkd :Ik l de fd;k tk ldkA lph&2 d i;kx l mit Hkh vf/kd ikIr gb rFkk eUdktc d vfrfjDr i;Dr dhVuk'kdk d vo'k"k Hkh irk yxu d Lrj l uhp ik; x;A

Tkhj d jkbtkLQ;j l iFkd fd; x; VkbdkMek d fofHkUu iFkDdkjdk e of)] Likjy'ku rFkk ok"I'khy ;k vok"Ik'khy fujk/kdk d mRiknu dk ydj Ik;kIr fofHkUurk, ik;h xbA

Ikk= i;kxk e iFkDdkjd CuTK 7-01, CuTa 7-02, CuTh 9-01 vkj CuTh 3-03 u thj d mdBk vkj dykth d tM xyu jkxtud dh of) dk 40 ifr'kr rd de fd;kA

lo{k.k d vk/kkj ij irk yxk fd chth; elkyk Qlyk e e[; :Ik l jlpld dhVk dh cgyrk Fkh ftue ie[k :Ik l pik] tflM] lQn eD[kh] iÿkh ekbuj] fFkIl] gkij ,o cx vkfn FkA thj ,o lkQ e pik dh itkfr;k d fu;=.k d fy; i;x e yk; x; ck;kj'kuy e l ofVflfy;e ylub dk iHkko lcl vPNk ik;k x;kA

ik= voLFkk e VkbdkMjek d dN idkj e thj e mdVk] dykth e tMxyu jkx d ifr 40 ifr'kr rd deh ikb xbA

2-1-4 eyHkr foKku

/kfu; e ruk ,o tM d Hkkj dk vuikr] ru ,o tM dh yEckb dk vuikr ,o bud 'k"d ,o rktk Hkkj dk vuikr lh/k mit dk iHkkfor djrk g ;Fkk de vuikr vf/kd mit dk n'kkrk gA ijUr lkQ e tM ,o ru dh yEckb dk vf/kd vuikr vf/kd mit dk vf/kd n'kkrh gA eFkh e bu vuikrk dk lEcU/k mit l ugh ik;k x;k] thj e tM ,o ru dh yEckb ,o Hkkj dk vf/kd vuikr vf/kd mit l lglEc/k n'kkrk gA

Ikk= ifjfLFkfr;k e , ,l ,] ikfyu ,o chVu gkbMkDykjkbM d dN mipkjk l dkf'kdk f>Yyh dh fLFkjrk e of) n[kh xbA bu jlk;uk d iHkko l /kfu; dh mit e lkFkd of) n[kh xbA

/kfu; e ru vkj tM dh yEckb dk vuikr tyh; ruko dh fLFkfr e egRoi.k ik;k x;kA ftu itkfr;k e ; vuikr de Fkk mudh mit vf/kd ik;h x;hA tyh;

ruko dh fLFkfr e ru ,o tM Hkkj vuikr vf/kd ik;k x;kA

vfre Qlykof/k fLFkfr e tyh; ruko gku ij lHkh itkfr;k e gfjryod dh ek=k e c<krjh n[kh x;hA itkfr vkLVfy;k] ,ylhlh&91] ,ylhlh&101 tyh; ruko dh fLFkfr e Hkh Vxj nkc dk cuk; g, FkhA tcfd vfre voLFkk e tyh; ruko gku ij rfud _.kRed Vxj nkc Hkh n[kk x;kA itkfr RCr-435, ACr-1, ND/Cor-60, Lokfr] l/kk] lk/kuk ,o vkLVfy;k e ruko dh fLFkfr e ok"Ik'khy ry dh ifr'krrk e of) ik;h xbA

dN ifrvkDlhdkjdk dk iHkko thj e mdBk jkx dh chekjh d fu;=.k e mi;kxh ik;k x;kA ikni jkx ifrjk/kh {kerk l lcf/kr to v.k tl dh fQuky] ¶yokukbM dk ik/k d ru ,o tM Hkkx e v/;;u fd;k x;kA itkfr thlh&4 e fQuky dh ek=k vf/kd ikb xbA

thj ,o /kfu; dh fofHkUu itkfr;k dk x.koRrk ,o vk"k/kh; v.kvk d fy, v/;;u fd;k x;kftle itkfr;k d e/; lkFkd vUrj ik;k x;kA

2-1-5 lkeft d foKku

o"k 2011&12 e chth; elkyk d mRiknu dh uohure rduhd dk in'ku dju gr dy 486 in'ku fdlkuk d [krk ij yxk; x; RkFkk 23 if'k{k.k dk;dek dk vk;kt u fd;k x;kA i{k= in'kuk e tk/kij ,o vtej e thj ¼vkjtM&209½ dh mit LFkkuh; itkfr dh vi{kk de'kh 62-11 ,o 46-19 ifr'kr vf/kd FkhA ;g of) mRRe chth] doduk'kh ,o mojdk d lefUor iHkko d dkj.k FkhA vtej ,o tk/kij e thj d fy; ykHk ykxr vuikr de'kh 4-95 ,o 3-61 ifr'kr ik;k x;kA ckjk fty e /kfu; e in'kuk e Hkh blh idkj of) ik;h x;h rFkk YkkHk ykxr vuikr 3-78 ik;k x;kA

jkt LFkkuk ,o xtjkr d fy, thvkb,l vkdMk dk l/kkj.k fd;k x;kA chth; elkyk Qlyk dh ,Vyl fuek.k d de e dF;ijd ekufp= Hkh r;kj fd;k x;kA

2-1-6 chth mRiknu

vkB chth; elkyk Qlyk de'kh thjk] /kfu;k lkQ] eFkh] fMy] vtok;u] dykth dk chtkRiknu fd;k x;kA thj dk 105 fDo- ,o vU; elkyk dk 10 fDo cht r;kj fd;k x;kA

2-1-7 rduhdh gLrkrj.k

dUn }kjk jk"Vh; m|kfudh fe'ku d vUrxr pkj d"kd if'k{k.k dk;de de'kh ,toky ¼fetkje½] lhdj] dkVk ,o irkix< e vk;kftr fd;k x;kA

nk vfxe ifDr in'ku t;ij ,o tlyej e vk;kftr fd;k x;kA lkQ ij ,d i{k= fnol euk;k x;kA

,d l/ku ipkj vfHk;ku fnukd 14&23 Qjojh 2013 dk vk;kftr fd;k x;kftle jktLFkku in'k e chth; elkyk Qlyk Riknu] x.koRrk l/kkj] dVkb mijkUr j[k j[kko ,o eY; lo/ku d ckje 0;kid ipkj ilkjfd;k x;kA

dUn }kjk fodflr itkfr;k ,o vU; rduhdk d in'ku gr vkj chth; elkyk l lcf/kr vU; tkudkfj;k dk ,d txg inf'kr dju gr chth; elkyk Kku {k= fodflr fd;k x;kA

o"k 2012&13 e fofHkUu in'kk l yxHkx 4000 fdlkuk u dUn e Hke.k fd;k ,o chth; elkyk l lcf/kr tkudkfj;k ikIr dhA

jk"Vh; fdlku eyk ,o lxk"Bh dk vk;ktu fnukd 15 Qjojh 2013 dk fd;k x;kftle yxHkx 1000 d"kdk u Hkkx fy;k ,o ykHkkfUor g,A lLFkku d oKkfudk u chth; elkyk l lcf/kr N% jfM;k ,o njn'ku ppkvk e Hkkx fy;kA dUn u vU;= lLFkkuk }kjk vk;kftr fdlku eyk e Hkkx fy;k rFkk viuh rduhdk dk in'ku fd;kA

dUn e 9 Lukrdkj Nk=k u viuh vul/kku ifj;ktukvk dk i.k fd;kA

dUn d nk ofj"B oKkfud mPp Lrjh; if'k{k.k gr 3 ekg d fy; fon'k x;A dUn d nk vU; oKkfudk u fon'k e Kku of) gr rFkk vUrjk"Vh; dk;'kkyk e Hkkx fy;kA

3. Executive Summary

The National Research Centre on Seed Spices under the aegis of Indian Council of Agricultural Research (ICAR) has completed 13 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 achievements

3.1.1 Crop improvement

NRCSS gene bank is strengthen by adding 208 germplasm of major seed spices and and 5 collections of minor seed spices which makes a total of 2007 lines. A total of 133 coriander, 68 cumin, 54 fennel, 208 fenugreek, 94 ajwain, 12 nigella, 14 dill , 18 anise and 36 celery lines were evaluated during the reporting year. Apart from this, 54 exotics lines of fenugreek received through ICARDA were also evaluated during this year. Variability was present among these fenugreek exotic lines, however, phenotypically it did not differed from the available germplasm from India.

In cumin 78 lines were evaluated for *Fusarium* wilt resistance in sick plot at NRCSS, Ajmer. GKKB-184, GKKB-190, AC-E-6 and AC-E-7 were found promising entries which showed tolerance against wilt.

Ample amount of variability was found in the germplasm set of anise genotypes. The range of variation was high for days to flowering, plant height, secondary branches, number of umbel per plant and days to maturity. Genotype Ani-14, Ani-15 and Ani-16 were most diverse among the set.

Two entries of fenugreek from NRCSS, namely AFg-3 and AFg-4 were evaluated in coordinated trial. AFg-3 and AFg-4 stood at second and third with 7.26 and 7.58 per cent higher yield than the national check, Hisar Sonali. Ten advanced lines were evaluated for different traits. On the basis of two year performance genotype AM-317 gave 12.89 per cent higher yield than best check variety AFg-2 (15.78 q/ha). AM-317 was identified for incorporation in the coordinated trial as AFg-5.

A total of 135 fenugreek lines of M_4 and M_5 generation were selected as variants for plant type, plant height, leaf shape and size and growth behaviour. Extent of variability created for powdery mildew incidence was also recorded.

One station trial was also conducted of stabilized mutants with higher productivity during 2011-12. A Mutant A3-28-9 having higher yield along with less powdery mildew incidence (30 PDI) has been submitted as AFg-6 for testing in coordinated trial in 2012-13.

In coriander twenty two advance populations were evaluated. Best population namely VDV/GL-173 and MKSM-1111 have been submitted for evaluation in coordinated trial as ACr-2 and ACr-3, respectively.

In fennel 21 selected genotypes were screened in a station trial at NRCSS. Two genotypes were found high yielding with dwarf nature namely AF-05-1-3 and AJ-FNL-2 and were included for coordinated trial in AICRP.

Among 12 test entries of dill two entries namely AD-S-01-3 and AD-S-01-24 gave higher yield than check varieties.

One gene pool of dill on the basis of yield and umbel characteristics developed in *rabi*, 2010-11 and advanced through close sib mating.

Fourteen selected genotypes of celery were screened in a station trial. Four genotypes namely A-Cel-8(Sel), Early celery, Cel-08 and A-Cel-5 were found superior over check variety. Among three genotypes of caraway one genotype OPA-CAR-1 was found superior over local check.

One genotype AA-93 of ajwain was identified for earliness in flowering which flowered 35-40 days early as compared to check.

Variability was observed among 10 advance line of nigella for yield attributes. Maximum seed yield was recorded in AN-21

Extent of variability in 13 varieties of fennel and 6 varieties of cumin was investigated using RAPD primers which detected an average intraspecific variations of 56.52% and 23.17% in banding patterns in fennel and cumin respectively. Ten gene sequences of fennel and 6 gene sequences of cumin have been submitted to NCBI, USA data base and are now available in public domain. Gene Accession numbers HQ 377206 to HQ 377215 of fennel and HM 176650 to HM 176655 of cumin assigned.

3.1.2 Crop Production

The profitable cropping system including fruit crops and seed spices was found with Aonla association. Among seed spices fenugreek association with fruit trees proved highly beneficial.

Application of irrigation through drip either with low pressure or conventional method proved better for getting higher yield, net return, benefit cost ratio and water use efficiency in fennel.

In cumin application of 100 percent N & P through vermi compost and enriched vermi compost is better for realizing higher yield.

Seed treatment + Soil application of *Pseu. Flu*. + Soil application of Neem cake @ 150 kg/ha + Foliar spray of sulphur compound resulted the lowest powdery mildew index in coriander and ST + SA of *Trichoderma viridie* + SA of NC @ 150 kg/ha +F.S. of sulphur compounds resulted lowest wilt incidence in cumin.

The lowest Alternaria blight index in cumin was observed with ST+SA of *Pseu.Flu*.+ SA of NC @ 150 kg/ha + F.S. of onion extract. The highest yield of coriander and cumin was obtained with the application of ST + SA of *Tricho.viridie* + SA of NC @ 150 kg/ha +F.S. of Karanj oil .

In fennel based cropping sequences the highest fennel yield was recorded in green gram-fennel – green manuring cropping sequence.

In fenugreek based cropping sequences high fenugreek yield was recorded in groundnut-fenugreek – green manuring cropping sequence. In cumin based cropping sequences the highest cumin yield was recorded in pearl millet - cumin- summer follow with summer solarization.

Among all the cropping sequences tested the highest fennel equivalent yield was recorded in cluster bean-cumin- green manuring sequence.

Early sowing of fennel on 10th October was more effective to increase the yield than mid and late sown condition. It also provided resistance to frost in fennel. Other seed spices viz. coriander, fenugreek, ajwain and nigella resulted higher yield on mid sown condition. The vegetative growth and yield of all seed spices under study except fennel was good in mid season sowing but lower in early and late season sowing.

Ajmer Ajwain-1 sown in mid season was better compared to Ajmer Ajwain-2. Ajad Kalongi variety of nigella sown in mid season resulted the highest yield.

Intercropping of seed spices with carrot resulted higher yield of fennel, coriander and ajwain compared with cabbage and pea.

The critical stage for weed competition in cumin, coriander and fenugreek were found 51, 35 and 31 days respectively.

Drip irrigation in cumin not only enhanced the yield by 41.07 and 23.05 % than flood and micro sprinkler irrigation methods but also improved the water productivity. Irrigation with micro sprinkler in kassuri methi enhanced the yield by 24.7 and 26.4 % and improved the water productivity by 22.5 and 8.1 kg grain/ha cm irrigation water as compare to flood and drip irrigation methods

Scaling up water productivity in cumin and nigella by applying irrigation through drip and conservation of moisture by mulching with 20 micron plastic sheet was found better for realizing higher yield and water use efficiency in nigella. In case of cumin, low pressure drip irrigation was found better.

Among different protected structures, plastic walk in tunnel proves significantly better for yield and its attributing characters in coriander. Yield (1582.16 kg/ ha) was highest in plastic walk in tunnel with 80% RDF. Minimum aphid population (20.1) was observed in the month of January in the plastic walk in tunnel as compared to structures studied.

In cumin, insect proof net exhibited significantly high plant height at harvest (28.73 cm), umbels per plant (12.83), seeds per umbellate (6.08), test weight (3.66 g) and seed yield (806.78 kg/ha) as compared to black net and open field.

Cumin genotypes differed in nutrient influx efficiency depending upon their growth stages. N, P, K, Mn, Zn and Cu influx rate was highest in GC-4 at 40 days. In fennel N, P, K and Mn influx rate up to 45 days was highest in genotype RF-101 while Cu, Fe and Zn influx rate at 45 days was higher in AF1-87. Nutrient influx rate in fenugreek cultivars Rajendra kranti and UM-35 was highest up to 35-40 days.

NPK and Zn uptake was highest in coriander with IW: CPE ratio 0.6 and least with 0.4 IW:CPE ratio. N and P uptake in fennel was highest with IW: CPE ratio 0.8. NPK and micronutrient uptake in fenugreek increased with increase in IW: CPE ratio.

Coriander has shown tolerance to soil acidity. Fenugreek yield was lower in acid soil as compare to neutral to higher pH, whereas coriander performed better in acid soils than the neutral to alkaline soils.

Twenty five coriander plant soil samples have been collected from Ajmer, Baran, Jhalawar and Kota Districts of Rajasthan for isolation of rhizospheric bacteria. Out of thirty six cultures fourteen were found superior.

Fennel grains dried under solar dryer, gave maximum test weight (5.17 gm), recovery (39.82 %) with lowest moisture content (61.30%) and highest taste marks (9.3) and colour marks (9.2) out of 10. Aluminum bag (vacuum packaging) was proved to be the best as compared to all the parameters in both fennel and cumin after 8 months of storage.

3.1.3 Crop Protection

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.

Disorders like yellowing in cumin and gummosis in fennel were found as emerging problems in some pockets of the cumin and fennel growing locations.

Surveillance of seed spice diseases on the Institute farm revealed that powdery mildew was a common disease appearing in all mandate seed spices crops except nigella. Other important diseases recorded were root rot and blight of dill, root rot of nigella, root rot, leaf spot and phyllody of anise in moderate to severe form.

Cumin wilt appeared in early crop stage, where as blight appeared during the month of January at pre flowering to flowering stage of the crop.

Positive correlation of temperature and powdery mildew appearance and spread was observed in fenugreek, coriander and cumin.

Phyllody (Witches broom) caused by phytoplasma and leaf spot caused by *Alternaria alternate* in anise are two new reports.

Twelve isolates of *Fusarium* and six isolates of *Alternaria* isolated from wilt and blight infected cumin plants were characterized based on morphological variations and sporulation.

Of the four application schedules tested for effective management of wilt, blight, powdery mildew and aphids in cumin, schedule S2 which comprised of seed treatment with tabuconazole and alternate spraying with mancozeb and propiconazole coupled with spraying of acetamiprid, imidachloprid and karathane resulted in significant reduction of wilt blight, powdery mildew and aphids incidence. The same schedule gave significantly high seed yield compared

to untreated control. Moreover, pesticide residue for S-2 schedule in cumin seed was found BDL except mancozeb where it was observed 1.9 to 2.0 µg /g.

The native *Trichoderma spp.* isolated from cumin rhizosphere showed variable reaction in colony growth, sporulation, and production of volatile and non volatile inhibitors.

The isolates CuTk 7-01, CuTa 7-02, CuTh 9-02 and CuTh 3-03 showed more than 40% growth inhibition against cumin wilt and nigella root rot pathogens in dual culture under *in vitro* conditions.

Sucking pests comprises the major pests complex of seed spices in all the crops. Major sucking pests associated with seed spices crops are aphids, jassids, white fly, leaf minor, thrips, hoppers and bugs and are found on crop since early stage to seed formation/maturation stage.

Among different biorational for control of Aphids *Myzus persicae* and *Apis gossypii* in cumin and fennel crop colonization of *V.lecanii* gave maximum control of both the species of aphids.

3.1.4 Basic Science

In coriander ratio of shoot to root weight, shoot to root length and fresh to dry weight showed direct effect on seed yield per plant i.e. less ratio give higher yield. Unlike coriander more shoot to root length ratio resulted in higher yield in fennel. In fenugreek ratio of shoot to root weight, shoot to root length and fresh to dry weight showed no direct relation with seed yield, however more shoot length and number of branches were recorded in the genotype giving higher yield. In cumin fresh weight, shoot weight and dry weight is invariably more in genotype GC 4 and produced more seed yield. High ratio of shoot to root weight and shoot to root length showed direct relation with seed yield in cumin.

In both cumin and coriander a few treatments of ASA, Proline and Betain hydrochloride showed increased membrane stability under *in vitro* conditions. Interestingly, in coriander, seed yield was significantly increased in many treatments of selected chemicals. In cumin, however yield was increased but magnitude was not as in coriander.

Under midterm water stress the ratio of shoot length to root length and shoot weight to root weight was found important as the genotypes showing higher yield maintained less shoot length to root length ratio under stress conditions, however, ratio of shoot to root weight was more under stress condition. Similar situation is there during terminal water stress. Genotypes Sadhna, ND/Cor 60 Sudha, YS/Rc 66 and Swati showed higher yield under terminal water stress conditions.

Total chlorophyll was more during terminal stress in most of the genotypes. Genotype Australia, LCC 91, LCC 101 were able to maintain more turgor pressure under midterm stress conditions while all the genotypes showed slightly negative turgor during terminal stress condition. Genotypes RCr 435, Acr1, Swati, Sudha, ND/Cor 60, Sadhna and Australia were showing more essential oil % either in midterm or terminal water stress conditions**.**

Effect of some antioxidants treatments to seeds and spray on standing crop was found effective in management of wilt disease in cumin. Plant defence related biochemical parameters such as total phenol and flavonoids were higher in wilt resistant plants in both GC 4 and RZ 209 genotypes of cumin.

Different genotypes of coriander and fenugreek were subjected to analysis of quality and medicinally important traits. Marked differences were observed among various traits in both the crops.

3.1.5 Social Science

Total demonstration conducted in 2011-12 were 486 covering 81 ha area. The full package of practices was given as intervention comprising improved variety, seed treatment and chemical weed management.

Twenty three training programmes on production technology of seed spices were also conducted along with demonstration in the reporting area for 1127 farmers. The average yield obtained under trials demonstrations for cumin (RZ-209) in Ajmer and Jodhpur district was 8.43q/ha and

6.14q/ha resp. The local cumin variety yield in Ajmer and Jodhpur district was found to be 5.2q/ha and 4.2 q/ha, respectively. Increase in yield due to combined effect of seed, fungicide and weedicide in Ajmer and Jodhpur for Cumin crop was 62.11 % and 46.19 %, respectively over local variety and the B: C ration of cumin in Ajmer and Jodhpur was 4.95 and 3.61 respectively.

The average yield obtained from coriander (RCr-436) was 14.53 q/ha in Baran district as compared to average yield of local variety (12.00 q/ha). Increase in yield due to combined effect of seed, weedicide and fungicide in Baran district was 21.08 % higher in RCr-436 as compared to local variety and B: C ratio for coriander crop in Baran district was 3.78.

A GIS database of seedspice has been prepared for Rajasthan and Gujarat. Thematic map had been generated for atlas. GIS database for rest of the states having seed spice cultivation is also under progress.

3.2 Seed Production

Eight seed spice crops namely cumin, coriander, fennel, fenugreek, dill, ajwain and nigella have been taken for seed production and a total of 105 quental of cumin seeds and 10 quentals seeds of other seed spice crops seeds have been produced.

3.3 Transfer of technology

The centre is also involved in transfer of proven technologies by conducting training programmes and demonstration trials of new varieties and production technologies.

NRCSS has organized four off campus farmers training to disseminate seed spices production technology under Natonal Horticulture Mission which include one training in NE region at Aizawl, Mizoram. Two frontline demonstrations were also conducted at Jaipur and Jaisalmer.

A field day on fennel crop was organized by NRCSS under NHM project on March 21, 2012 at Bhadal, Jaipur.

A mass campaign week (14 -23, Feb, 2013) was organized in seed spices growing areas of Rajasthan for dissemination of technologies for improvement in quality of seed spices, their post harvest handling, processing and value addition.

A Seed Spices Knowledge Area was developed in the project "Intellectual property management and transfer/commercialization of agriculture technology scheme" and Inaugurated on 15th February 2013. All the technologies developed at NRCSS are displayed through posters and live samples.

During 2012-13 about 4000 famers, students from different states, mainly form Rajasthan, Gujarat, Punjab, Haryana, U.P., UttaraKhand, M.P., Himachal Pradesh, Jharkhand and Maharashtra visited the centre under various training and visit programme.

A National Kisan Mela and Kisan Sanghosthi was organized on 15th February 2013 on the Mela ground of NRCSS. Around 1000 farmers, agriculture students, teachers, scientists and traders participated in the event.

Scientists from NRCSS have delivered six television talks and one radio talk on seed spices related issues during the reporting period.

NRCSS also participated in seven kisan mela organized by different institutions and exhibited the technologies.

Nine students did their M.Sc. Project work during the reporting year under the guidance of NRCSS scientists. Two scientists have undergone three months advance training to USA in the core subjects of Horticulture. One scientists from NRCSS attended International Conference and food expo held at USA. One scientist made a study visit of 15 days to USA.

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 as 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 12.20 lakh ha with production of 10.58 lakh tones annually. In India, major area covered under different seed spices is 5.31 lakh ha in coriander, 5.08 lakh ha in cumin, 0.81 lakh ha in fenugreek, 0.62 lakh ha in fennel and 0.26 lakh ha in ajwain with their production in the country is 4.82, 3.14, 1.18, 1.05 and 0.22 lakh tones respectively. The productivity of coriander, cumin, fenugreek, fennel and ajwain is 9.1, 6.2, 14.6, 17.1 and 8.6 q/ha respectively. The area, production and productivity of seed spices over the year from 2002-03 to 2011-12 are present in Annexure I.

The prevailing world wide demand of seed spices is more than 200000 tones, of which India alone contributes 142300 tonnes annually valued at ` 9855.8 crores. India is exporting only 10.87 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 increase our production levels. 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 us in international markets.

India commands leading position in world spices trade with 48% (502750 tonnes) share in volume and 43% (` 5560.5 crores) in value. The seed spices export from India has registered an all time high both in term of quantity (142300 tonnes) and value (` 985.58 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 the centre at Ajmer during IXth five year plan. Thus, this centre was set up with a broad-based framework to address diverse seed spice cultivation 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 as seed spices plays an important role in national economy. The Centre has now completed a decade and has

achieved a level of understanding seed spice crops, which has helped to create a strong impression among all the stakeholders involved with seed spices and has been successful in providing technologies for 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 on the Ajmer-Beawar road 13 km away from Ajmer railway station. Ajmer city is well connected by road and railway line to Ahmedabad and Delhi with distance of 516 km and 388 km, respectively in opposite directions. The nearest airport is Jaipur, situated about 125 km away from Ajmer.

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

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

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.)

Table 1: Agro meteorological data for the year 2011-12

Month	Temperature (^{o}C)		Relative Humidity (%)		Rainfall (mm)
	Maximum	Minimum	At 8.30	At 17.30	
April,2011	36.70	26.63	29.27	14.03	-
May,2011	39.39	29.34	31.52	13.87	-
June,2011	38.73	29.87	58.00	40.70	93.0
July,2011	33.94	27.81	80.55	59.82	68.00
August,2011	31.71	27.03	80.45	31.71	112
Sept,2011	31.47	25.67	58.33	34.43	98.30
Oct,2011	34.24	24.18	44.39	21.74	-
Nov,2011	37.48	18.10	49.23	30.27	-
Dec,2011	25.68	9.08	54.55	35.52	-
Jan,2012	22.18	6.68	57.26	32.19	-
Feb,2012	25.32	10.54	54.61	31.93	-
March,2012	32.21	17.42	34.55	16.58	-

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.

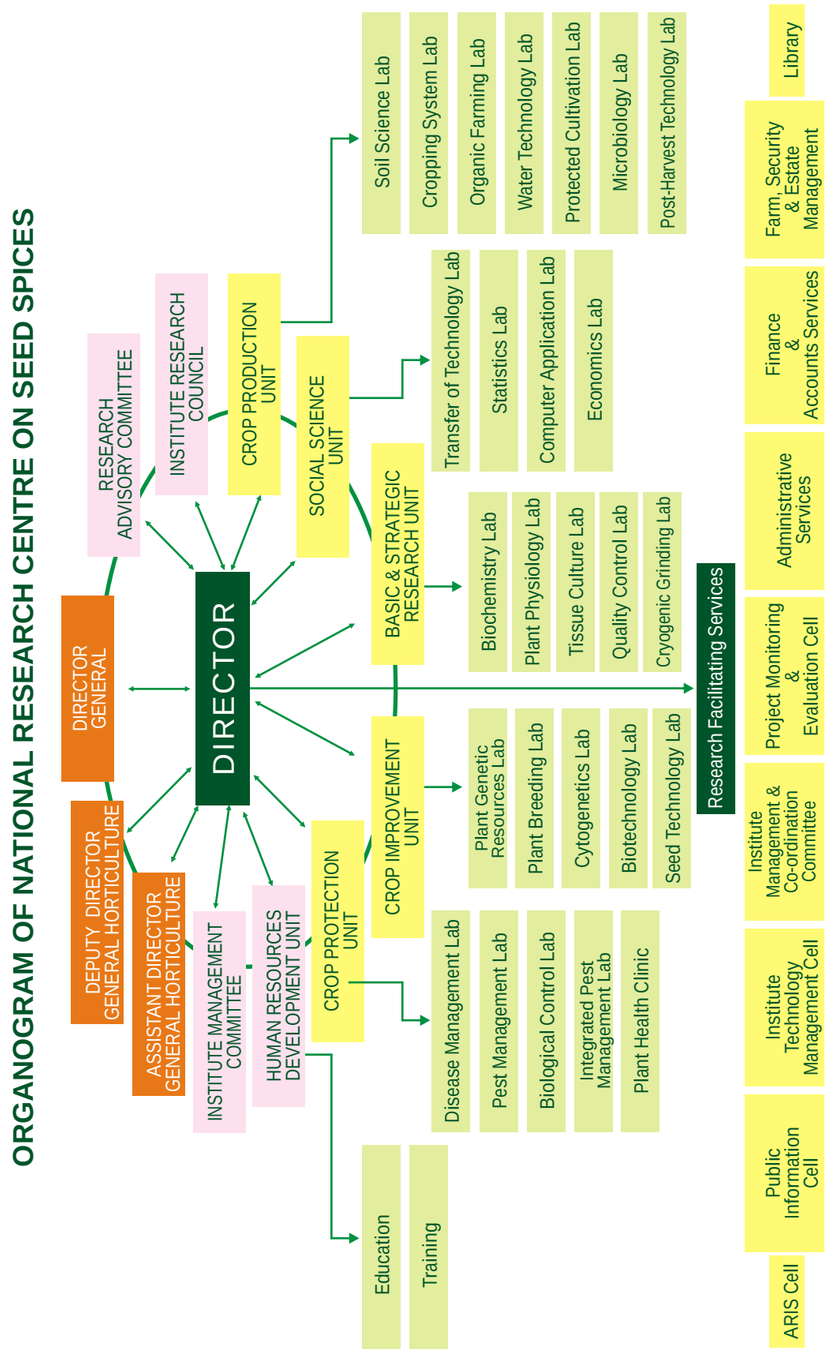
4. Fenugreek (*Trigonella foenum-graecum, Trigonella corniculata* L.)
5. Ajwain (*Trachyspermum ammi* Sprague)
6. Dill (*Anethum graveolens* L., *Anethum sowa* Kurz.)
7. Nigella (*Nigella sativa* L.)
8. Anise (*Pimpenella anisum* L.)
9. Celery (*Apium graveolens* L.)
10. Caraway (*Carum carvi* L.)

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.

4.2 Financial Outlay

HEAD	PLAN		NON- PLAN	
	RE 2012-13	Expenditure	RE 2012-13	Expenditure
Establishment	–	–	267.36	253.93
TA	6.00	6.00	1.99	1.99
Other charges including equipment	5.03	5.03	6.37	6.37
Information Technology	4.89	4.89	–	–
Library Books & journals	10.08	10.08	–	–
Works	–	–	–	–
HRD	6.00	6.00	2.48	2.48
Furniture & Fixture	–	–	1.63	1.64
Total Rsch & opnl expenses	55.00	55.00	33.65	33.66
Total Admn expenses	38.00	36.02	71.00	71.00
Guest House - Maintenance	–	–	1.07	1.07
Other Miscellaneoues	–	1.98	7.04	7.04
Total	125.00	125.00	392.59	379.18



5. Research Achievements

5.1 Crop improvement

5.1.1 Collection, evaluation and documentation of plant genetic resources of seed spices

All the collected and already available germplasm is being maintained at NRCSS. During 2011-12, early flowering coriander, cumin, dill, ajwain, nigella, anise, celery and caraway germplasm was maintained. A total of 133 coriander, 68 cumin, 54 fennel, 208 fenugreek, 94 ajwain, 12 nigella, 14 dill, 18 anise and 36 celery lines were evaluated during the reporting year.

NRCSS gene bank have total germplasm collection of 2007 seed spices as on March, 2013 (Table 5.1).

Apart from this, 54 exotic lines of fenugreek received from ICARDA were also evaluated during this year. The variability present in these exotic lines, however, phenotypically it differed from the available germplasm from India.

Management of plant genetic resources of cumin

In cumin 78 lines were evaluated for fusarium wilt resistance in sick plot at NRCSS, Ajmer. GKKB-184, GKKB-190, AC-E-6 and AC-E-7 were found promising which showed tolerance against wilt. Remaining lines showed wilt incidence from 80-100%. Few survivals were noticed, which were selected for advancement.

Genetic diversity analysis in anise

Eighteen genotypes were evaluated for all the major descriptor traits. Ample amount of variability was found in the germplasm set. The range of variation was high for days to flowering. Genotype Ani-17 flowered in 82 days, whereas the late genotype Ani-1 flowered in 112 days. Likewise high range of variation was observed for plant height (42 to 70 cm), secondary branches (10.6 to 20.4), number of umbel per plant (34.4 to 54.4), and days to maturity (114 to 135 days). Diversity index was estimated among the eighteen lines, Genotype Ani-14, Ani-15 and Ani-16 were most diverse among the set. Nearly 100 single plants were selected based on various traits to enhance the yield potential and to improve other component traits.

5.1.2 Breeding for improvement in major seed spices

Evaluation of fenugreek genotypes

Two entries from NRCSS, namely AFg-3 and AFg-4 were found superior in coordinated trial on fenugreek conducted during 2009-10, 2010-11 and

Table 5.1 Total germplasm assemblage at NRCSS

Crop	NRCSS Collection				NAGS holding
	Indigenous	Exotic	Lost	Total	
Cumin	70	7	-	77	217
Coriander	141	3	27	117	490
Fenugreek	81	59	6	134	732
Fennel	103	3	75	31	282
Ajwain	94	1	9	86	95
Dill	100	5	3	102	105
Nigella	19	3	-	22	22
Celery	36	-	-	36	36
Anise	18	-	-	18	18
Caraway	8	2	8	2	10
Total	670	83	128	625	2007

2011-12 at 12 locations around the country including Guntur, Dholi, Udaipur, Jabalpur, Faizabad, Hisar, Ajmer, Jobner, Coimbatore, Jagudan, Pantnagar and Raigarh. AFg-3 and AFg-4 stood at second and third with 7.26 and 7.58 per cent higher yield than the national check Hisar Sonali.

Ten advanced lines were evaluated with three check varieties namely AM-1 (AFg-1), AM-2 (AFg-2) and RMt-1 using three replications. Performance of these lines for different traits is presented in Table 3. AM-317 was the highest yielder with 22.44 q/ha as compared to best check i.e. AM-2 with 18.64 q/h seed yield.

On the basis of two year performance, genotype AM-317 gave 12.89 per cent higher yield than best check variety AFg-2 (15.78 q/ha). AM-317 was identified for incorporation in coordinated trial as AFg-5.

Table 5.2 Performance of fenugreek advance lines for yield in 2010-11 and 2011-12.

Genotypes	2010-11	2011-12	Mean	% higher over AFg-2
AM - 288	1705.5	1073.89	1389.7	-11.93
AM - 317	**2244.75**	**1317.95**	**1781.35**	**12.89**
AM - 324	1992	1161.15	1576.58	-0.09
AM - 326	1732	1041.81	1386.91	-12.11
AM - 329	1923.75	994.87	1459.31	-7.52
IC - 144225	2050.25	1180.81	1615.53	2.38
J. Fenu - 221	2100.75	1135.86	1618.31	2.56
LFC - 49	2166.75	1371.06	1768.91	12.1
UM - 146	1653	1497.34	1575.17	-0.18
UM - 344	2155	1260.81	1707.91	8.23
AFg-1	1759.25	1156.48	1457.87	-7.61
AFg-2	1864.25	1291.72	1577.99	0
RMT -1	1655.25	914.67	1284.96	-18.57
CD at 5%	**148.17**	**157.72**		
CV (%)	**10.75**	**7.9**		

Creation of variability in fenugreek through mutation breeding

Mutation breeding programme was started with three genotypes of fenugreek. This year total 135 lines of M_4 and M_5 were sown in single row of 2 metre length in Augmenmted design with three parents as check. These lines were selected as variants for plant type, plant height, leaf shape & size and growth behaviour were selected. Extent of variability created for powdery mildew incidence was also recorded and given in table 5.3.

Table 5.3 Extent of Variability observed in mutants in M5 & M4 generation

Variety	Radiation Dose (gys)	Powdery mildew incidence			
		Mean	Min	Max	CV
RMt-1	100	43.43	25.93	60.93	56.99
	200	67.26	60.93	75.93	9.66
	300	59.62	35.93	92.59	28.41
	400	50.09	40.93	60.93	15.99
	500	44.07	34.26	79.26	31.21
RMt305	100	76.76	64.26	94.26	14.12
	200	66.57	40.93	94.26	22.41
	300	73.43	70.93	75.93	3.93
	400	33.43	25.93	45.93	28.64
	500	64.19	27.59	94.26	30.67
UM-344	100	39.68	22.59	54.26	22.41
	200	53.65	32.59	90.93	33.98
	300	48.96	25.93	70.93	28.92
	400	68.84	52.59	87.59	18.92
	500	-	-	57.59	-

One station trial was also framed from stabilized mutants with higher productivity and it was taken as fenugreek Station trial II during 2011-12. The mutant A3-28-9 having higher yield along with less powdery mildew incidence (30 PDI) has been submitted as AFg-6 for testing in coordinated trial started in 2012-13.

Breeding for high yield and quality in coriander

This project was started from 2007-08 year with the objective of developing genotypes having high yield and good quality i.e. higher essential oil content. The station trial was repeated during the year. Twenty two advance populations were evaluated in RBD with four check varieties namely RCr-435, Ajmer Coriander-1, RCr-41 and Hisar Sugandh. There was severe damage due to frost to all the entries. On the bais of performance during 2010-11 best population namely VDV/GL-173 and MKSM-1111 have been submitted for evaluation in coordinated trial as ACr-2 and ACr-3, respectively.

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

This project was started in 2009. In this year 21 selected genotypes were screened in a station trails at NRCSS. Two check varieties namely AF-1 (11.04 q/h & 132 cm) and RF-125 (11.02 q/h & 125 cm) were used in trial. Among the 21 genotypes two genotypes were found high yielding namely AF-05-1-3 (17.76 q/h &139 cm) and AJ-FNL-2 (13.23 q/h & 122 cm). Both genotypes are included in AICRP for coordinated trails (Fig. 1).

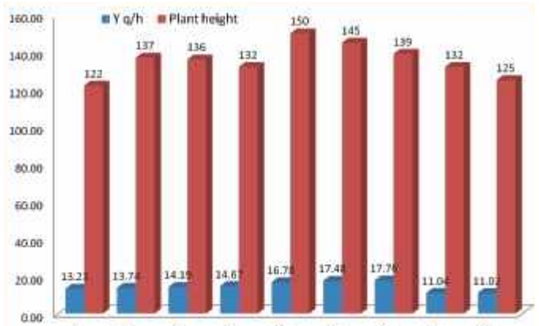


Fig. 1 Performance of fennel genotypes during 2011-12

5.1.3 Breeding for improvement in minor seed spices

Breeding for high yield and quality in dill

One station trial was conducted with 12 test entries and two check varieties namely AD-1 and AD-2. The best check variety AD-1 gave 1025.0 kg/ha seed yield and it was at par with another check. The test entries AD-S-01-3 and AD-S-01-24 gave higher yield than check varieties (Fig. 2).

Fig 2 Performance of dill genotypes in station trial during 2011-12

Creation of variability in dill through gene pool approach

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

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

This project was started in 2009. In this year, fourteen selected genotypes were screened in a station trial at NRCSS in RBD of three replication comprising one check variety namely A-Cel-1(2.6 q/h). Among the fourteen genotypes four genotypes were found superior over check variety, namely A-Cel-8(Sel) (4.38 q/h), Early celery (4.09 q/h), Cel-08 (3.69 q/h) and A-Cel-5 (3.42q/h) (Fig. 3).

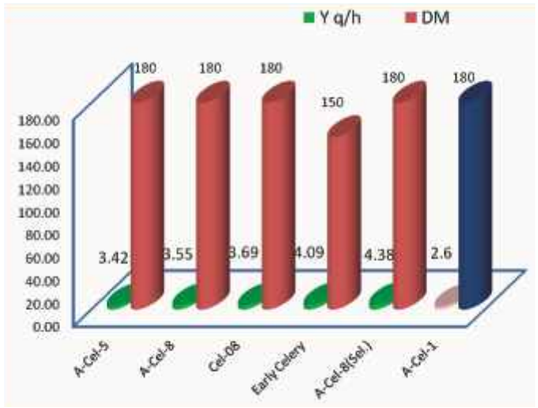


Fig. 3 Performance of celery genotypes in station trial

Three selected genotypes of caraway were screened in a station trails at NRCSS. Among these three genotypes one genotype was found superior over local check namely OPA-CAR-1 (0.53 q/h).

Breeding for high yield and quality in ajwain

On the basis of the previous year's observation one station trial was conducted with 10 test entries and three check varieties namely, Ajmer Ajwain-2, GA-1 and Lam Sel-2 during 2011-12. The flowering in genotype AA-93 was found 35-40 days early as compared to checks. This genotype was identified for earliness.

Ajwain genotype AA-93

Breeding for high yield and quality in nigella

Station trial was conducted on 10 advance lines of nigella with 3 check varieties namely Ajmer Nigella-1, Pant Krishna and Azad Kalongi. Plant height, number of branches, days to 50 % flowering, yields attributing traits and seed yield (kg/h) was recorded. The maximum seed yield were recorded in AN-21 (Table 5.4).

Table 5.4 Yield and it's attributes in nigella genotypes station trial

Genotype	No. siliqua/ plant	No. of seeds per siliqua	Seed yield kg/ ha
KKN-Sel-10	56.00	82.87	764.17
Azad Kalongi	56.93	72.07	363.33
Pant Krishna	37.40	72.07	386.67
AN-23	46.40	77.60	708.33
AN-22	47.00	84.73	852.78
AN-21	66.60	94.07	1099.72
AN-20	51.17	80.13	683.33
AN-06	43.73	82.47	803.33
AN-04	38.73	82.47	629.44
AN-S-7	48.07	86.53	357.67
AN-S-5	36.07	87.33	820.56
KKN-Sel-9	79.27	80.83	832.22
AN-1	63.13	75.27	788.89
S.Em±	**2.13**	**2.10**	**42.97**
CD(0.05)	**6.21**	**6.14**	**125.41**
CV(%)	**7.14**	**4.47**	**10.64**

Nigella genotypes at station trial during 2011-12

5.1.4 Deciphering molecular diversity and molecular characterization in seed spices

Genetic characterization and documentation of released varieties of cumin, coriander, fenugreek and fennel

Morphological observation of yield and yield contributing characters were taken for all the released varieties available. The extent of genetic variation among the indigenous varieties of fennel (*Foeniculum vulgare*) and cumin (*Cuminum cyminum* L.) was found limited for phenotypic and genetic markers. Multilocus genotyping by RAPD primers detected an average of intraspecific variations amounting to 56.52% and 23.17% polymorphism in banding patterns in fennel and cumin, respectively (Fig. 4 & 5). Six cumin varieties exhibited a uniform ITS length of 600bp with single nucleotide polymorphisms (SNPs). Besides total ITS length variations and SNPs, INDELS were also detected at several sites in ITS-1 region of fennel. Multiple sequence alignment of ITS region is of phylogenetic significance in distinguishing and cataloguing of fennel and cumin germplasm. Eventually, the knowledge of their genetic relationships and intra-specific diversity will be of significance in developing intra-specific crosses of fennel and cumin in ongoing seed spices breeding programme. Ten gene sequences of fennel and 6 gene sequences of cumin have been submitted to NCBI, USA public domain data base.

Gen Accession numbers HQ 377206 to HQ 377215 of fennel and HM 176650 to HM 176655 of cumin have been assigned.

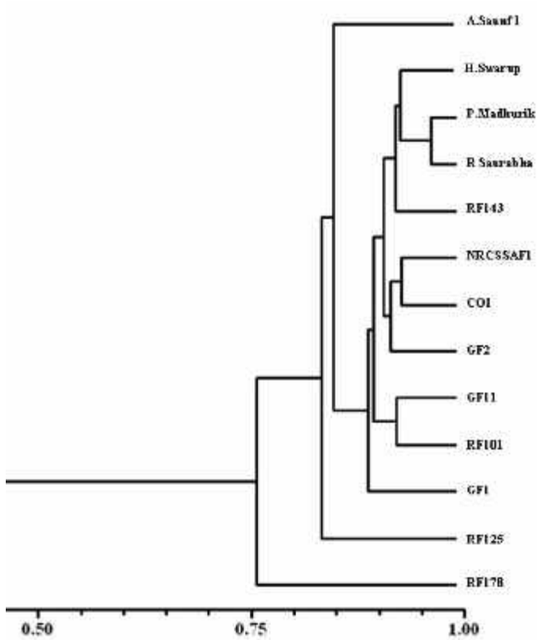


Fig. 4 Dendrogram of 13 varieties of F. *vulgare* based on 10 RAPD informative primers.

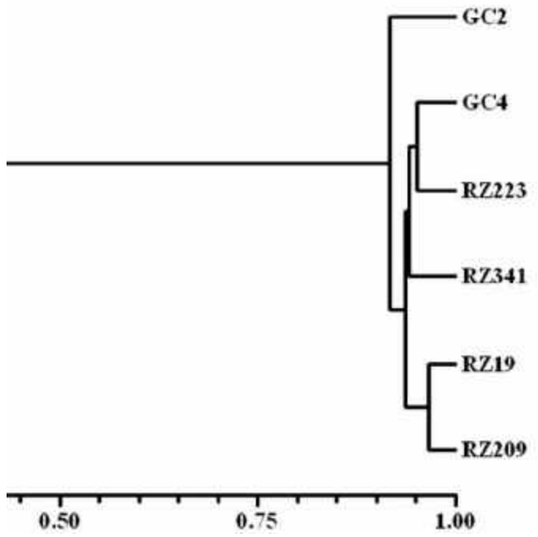


Fig. 5 Dendrogram of 6 varieties of *C.cyminum* based on 9 RAPD informative primers

Genetic diversity analysis through biotechnological tools in fenugreek

Genetic diversity has been calculated among 75 germplasm lines of fenugreek including released varieties using RAPD markers. Out of twenty primers, 15 amplified a total of 2469 RAPD bands. Out of this 385 bands were polymorphic with 15.59% polymorphism, thus revealing a low degree of polymorphism where as it was high (57.66%) among the released varieties which indicates that there is duplicity in collected germplasm. Cluster analysis of 1 - 0 bivariate data using UPGMA method delineated the genotypes into three 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.

PCA analysis was further carried out (Fig. 6) showing ample amount of variation.

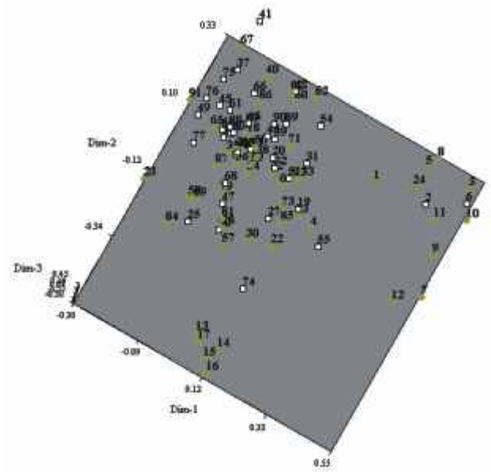


Fig. 6 Three dimensional graph based on PCA using RAPD markers.

Genetic diversity analysis in cumin

Genetic diversity was calculated among 55 germplasm lines of cumin including 6 released varieties using RAPD markers. Out of twenty primers, 15 amplified a total of 1191 RAPD bands. Out of this 218 bands were polymorphic with 18.30% polymorphism, thus revealing a low degree of polymorphism where as it was high (66.66%) among

the released varieties which indicates that there is duplicity in collected germplasm. Cluster analysis of 1 - 0 bivariate data using UPGMA method delineated the genotypes into three 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.

PCA analysis was further carried out which showed high amount of variation (Fig. 7).

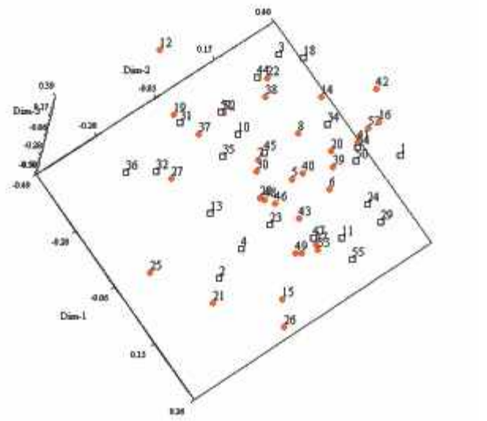


Fig 8 Three dimensional graphs based on PCA using RAPD markers.

5.1.5 Basic and applied studies on artificial hybridization in major seed spices

Standardization of Technologies for crossing in coriander (*Coriandrum sativum* L.)

Three chemicals viz GA_3, 2, 4-D, Maleic hydrazide and absolute alcohol were tested for pollen sterility induction in coriander variety ACr-1. The different concentration of these chemicals were (GA_3: 50,100, 150, 200, 250 & 300 ppm; 2,4-D: 10, 50, 100 150, 200 & 500 ppm; Maleic hydrazide: 75, 100, 125, 150, 200 & 250 ppm and absolue alcohol) sprayed at flower primodia initiation stage @ 25 ml per plant. After full anthesis the pollen sterility were tested by staining with 1% acetocarmine solution. Two chemicals 2,4-D and MH induced sterility up to more than 50%.

5.2 Crop Production

5.2.1 Cropping system and weed management in seed spices

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 with Aonla association. The next highest yield of seed spices was achieved with Aonla association. The fruit yield of Ber and Aonla was also recorded. Yields were converted into coriander equivalent yield (kg/ ha). 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 with inter-cropped fenugreek

Aonla with inter-cropped fenugreek

Table 5.5 Effect of different irrigation methods at varying crop configuration on gross return, net return and BCR of fennel (Mean of two year)

Treatments	Seed yield Kg /ha	WUE kg/ha/mm	Cost of cultivation (`/ha)	Net Return (`/ha)	BCR
Irrigation methods					
Conventional	1534	3.41	20500	48540	2.37
All furrow	1767	4.74	23500	56032	2.38
Alternate furrow	1373	4.32	22500	39297	1.75
Alt to Alt Furrow	1431	4.48	22500	41892	1.86
Conventional drip	2105	6.14	26000	68732	2.64
Low Pressure drip	2137	6.24	25500	70662	2.77
CD (P=0.05)	132	3.41	-	5914	0.25
Crop geometry					
Normal row arrangement	1789	-	23417	57068	2.42
Paired row arrangement	1661	-	23417	51317	2.17
CD (0.05)	**71**	**-**	**-**	**3192**	**0.13**

Evaluation of irrigation methods in fennel under various configuration of crop geometry

Application of irrigation through drip with low pressure or conventional method proved better for getting higher yield (2137 kg/ha), net return (`70662 /ha), benefit cost ratio (2.77) and water use efficiency (6.24 kg /ha/mm) followed by all furrow irrigation. Further, it has been observed that beside drip, all furrow irrigation method proved better over conventional and alternate furrow irrigation system. All furrow method of irrigation yielded 15 and 20 per cent higher grain and straw yield, respectively over conventional irrigation (Table 5.5).

Standardization of package for organic seed spice production (Coriander and Cumin)

In cumin application of 100 percent N & P through vermi compost and enriched vermi compost is better for realizing higher yield but in coriander the higher yield can be realized with application of 100 percent N & P either through vermi compost and enriched vermi compost, sheep manure and enriched vermi compost or 75 per cent N&P through vermi compost, enriched vermi-compost + seed inoculation with *Azotobactor* and PSB. Seed treatment + Soil application of *Pseu.Flu*. + Soil application of Neem cake @ 150 kg ha + Foliar spray of Sulphur compound resulted the lowest powdery mildew index in coriander and ST + SA of *Tricho. viridie* + SA of NC @ 150 kg ha +F.S. of Sulphur compounds resulted lowest wilt incidence cumin. The lowest blight index in cumin was observed with ST+SA of *Pseu.Flu*.+ SA of NC @ 150 kg ha + F.S. of onion extract. The highest yield of coriander and cumin was obtained with the application of ST + SA of *Tricho.viridie* + SA of NC @ 150 kg ha +F.S. of Karanj oil . The highest yield attributes and yield of coriander and cumin was recorded with insect pest control by Spray of Sulphur compound of Karanj extract-1% (T_7) which is at par with application of Allylisothio cynate-1 percent and application of neem oil-2 percent.

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

In fennel based cropping sequences the highest fennel yield (1650 kg/ha) was recorded in green gram – fennel – green manuring cropping sequence followed by green gram – fennel – summer fallow and black gram – fennel – green manuring cropping sequence. In fenugreek based cropping sequences the higher fenugreek yield (1525kg /ha)

was recorded in groundnut – fenugreek – green manuring cropping sequence being at par with groundnut – fenugreek – summer fallow. In cumin based cropping sequences the highest cumin yield of 690 kg/ha was recorded in pearl millet - cumin-summer fellow with summer solarization followed by cluster bean – cumin – summer fallow with summer solarization. Among all the cropping sequences the highest fennel equivalent yield (8316 kg /ha) was recorded in cluster bean – cumin – green manuring sequence followed by cluster bean – cumin – soil solarization. The highest net return of ` 336560/- per ha was recorded in cluster bean- cumin- green manuring cropping sequence followed by cluster bean – cumin – soil solarization which is statistically at par but the highest benefit cost ratio of 9.17 was obtained in cluster bean – cumin – soil solarization cropping sequence followed by cluster bean- cumin-green manuring cropping sequence.

Effect of date of sowing, crop geometry and varieties on performance of seed spices under different agro-climatic conditions

Early sowing of fennel on 10th October was more effective to increase the yield than mid and late sown condition and resistant to frost than other seed spice crops. Other seed spices viz. coriander, fenugreek, ajwain and nigella resulted higher yield on mid sown condition. The vegetative growth and yield of all seed spices under study except fennel was good in mid season sowing but lower in early and late season sowing.

In fennel variety RF-125 sown in early season resulted the highest yield attributes and yield (10.41 q/ha). RCr-436 variety of coriander sown in mid season resulted the highest yield attributes and yield (18.97 q/ha). AFg-2 sown in mid season proved superior over all other varieties and resulted the highest yield attributes and yield (17.93 q/ha). Ajmer Ajwain-1 sown in mid season was better compared to Ajmer Ajwain-2. Ajad Kalongi sown in mid season resulted the highest yield (13.12 q/ha).

Inter-cropping of seed spices in vegetables (AICRP on Vegetables)

In the study three seed spices *viz*. fennel, ajwain and coriander with three vegetables viz. pea, cabbage and carrot were taken. Results revealed that all the vegetables viz. carrot, cabbage and pea performed better with fennel compared to ajwain and coriander and accordingly exhibited higher vegetable yield. Inter-cropping of seed spices with carrot resulted higher yield of fennel, coriander and ajwain compared with cabbage and pea. Inter cropping of fennel with cabbage resulted the highest fennel equivalent yield (27.37q /ha) and net return (` 134,15/- per ha) followed by with carrot + fennel. The highest benefit cost ratio of 4.76 was obtained in carrot + fennel intercropping followed by with cabbage + fennel (Table 5.6).

Table 5.6 Effect of intercropping of seed spices with vegetables on yield, return and BCR 2011-12

Sr. No	Treatment	Yield qt/ha		Fennel equivalent yield (qt/ha)	Cost of cultivation (`/ha)	Gross return (`/ha)	Net return (`/ha)	BCR
		Vegetable (fresh)	Seed spice					
1	Pea+ Fennel	32.25	16.25	21.63	26375	129750	103375	3.92
2	Pea+ Coriander	28.25	8.25	11.58	24800	69500	44700	1.80
3	Pea +Ajwain	30.5	7.75	15.42	22475	92500	70025	3.12
4	Cabbage+ Fennel	145.4	15.25	27.37	30075	164200	134125	4.46
5	Cabbage +Coriander	118.4	9.25	17.58	28500	105450	76950	2.70
6	Cabbage +Ajwain	126.6	8.45	21.82	26175	130900	104725	4.00
7	Carrot+ Fennel	110.4	17.25	26.45	27575	158700	131125	4.76
8	Carrot +Coriander	92.25	9.4	15.52	26000	93125	67125	2.58
9	Carrot + Ajwain	98.25	8.75	19.85	23675	119125	95450	4.03
	CD(0.05)	**10.94**	**1.16**	**2.06**	**-**	**-**	**-**	**-**

Identification of critical stage for weed management in seed spices

Weed flora of the experimental field consisted of *Chenopodium murale* L., *Chenopodium album* L., *Cynodon dactylon* L. and *Cyperus rotundus*. Maximum seed yield of cumin, coriander and fenugreek (645.8, 1262.5 and 2387.5 kg/ha) were recorded with the weed free throughout growth period treatment, where as lowest yield was recorded at weedy check plots, respectively (Table 5.7). The critical stage for weed competition in cumin, coriander and fenugreek were found 51, 35 and 31 days respectively (Fig 4). The loss in yield due to weeds (weedy throughout growth) in fenugreek, coriander and cumin were 629.5, 919.2 and 1675.0 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 22.57-97.47% in cumin to 12.27- 72.8 % in coriander and 21.41-70.1 % in fenugreek as compared with weed free plots (Fig. 8).

5.2.2 Precision farming in seed spices

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 baby corn yield was 3625, 3756 and 3014 kg/ha under flood, drip and micro sprinkler irrigations, whereas the yield was 3515, 4055 and 2825 kg/ha with flat bed, raised beds of 75 and 150 cm width. Three irrigation measuring 13.46, 5.41 and 4.08 ha cm water was given under flood, drip and micro sprinkler irrigation. Under land configuration treatments the irrigation water delivered was 7.78, 7.67 and 7.50 ha cm with flat, 75 and 150 cm wider beds (Fig. 9).

After harvest of the baby corn, cumin variety GC-4 was sown on 11-11-2011. Five irrigations were given to the crop measuring 30.81, 10.84 and 15.55 ha cm water through flood, drip and micro sprinkler systems (Table 5.8). Whereas 19.62, 17.68 and 19.49 ha cm water was delivered under flat, raised beds (75 cm) and wider beds (150 cm). Results show

Table 5.7 Grain yield of cumin, coriander and fenugreek under different treatments of weedy and weed free period DAS (days after sowing)

Treatment	Seed yield (kg/ha) Cumin	Coriander	Fenugreek
Weedy up to 15 DAS (T)	500.0	1107.5	1876.3
Weedy up to 30 DAS (T_2)	294.0	1090.8	1765.8
Weedy up to 45 DAS (T_3)	216.0	954.2	1500.0
Weedy up to 60 DAS (T_4)	155.4	804.2	1494.2
Weedy up to 75 DAS (T_5)	119.8	548.3	1083.8
Weedy up to 90 DAS (T_6)	53.1	481.7	931.7
Weedy throughout (T_7)	16.3	343.3	712.5
Weed free up to 15 DAS (T_8)	74.0	644.2	1481.7
Weed free up to 30 DAS (T_9)	109.1	876.7	1664.6
Weed free up to 45 DAS (T_{10})	201.9	1187.5	1740.0
Weed free up to 60 DAS (T_{11})	299.6	1200.4	1786.3
Weed free up to 75 DAS (T_{12})	392.1	1210.4	
Weed free up to 90 DAS (T_{13})	464.2	1246.7	2245.4
Weed free throughout (T_{14})	645.8	1262.5	2387.5
SE(m)	16.41	36.17	33.96
CD at 5%	**47.50**	**103.85**	**97.52**

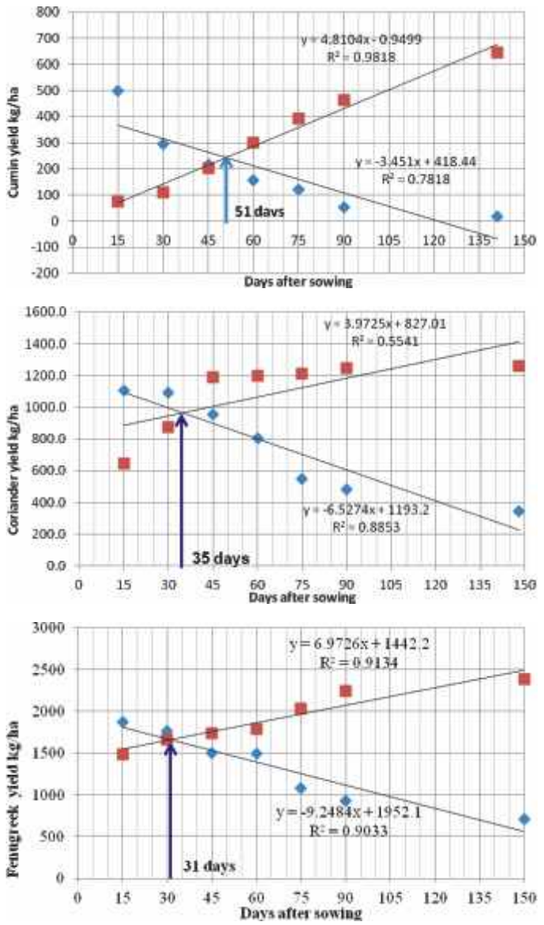


Fig. 8 Critical stage (days after sowing) for weed competition in cumin, coriander and fenugreek

that irrigation with drip not only enhanced the yield by 41.07 and 23.05 % than flood and micro sprinkler irrigation methods but also improved the water productivity and gave 41.3 kg seed/ha cm irrigation water. The improvement in water productivity with drip irrigation was 32.85 and 19.55 kg seed/ha cm irrigation water than the flood and micro sprinkler irrigation. Sowing of 3 rows of cumin on raised beds (75 cm) enhanced the grain yield by 42.72 and 41.28 % and water productivity by 15.13 and 13.61 kg grain/ha cm irrigation water than flat bed and wider raised beds (150 cm).

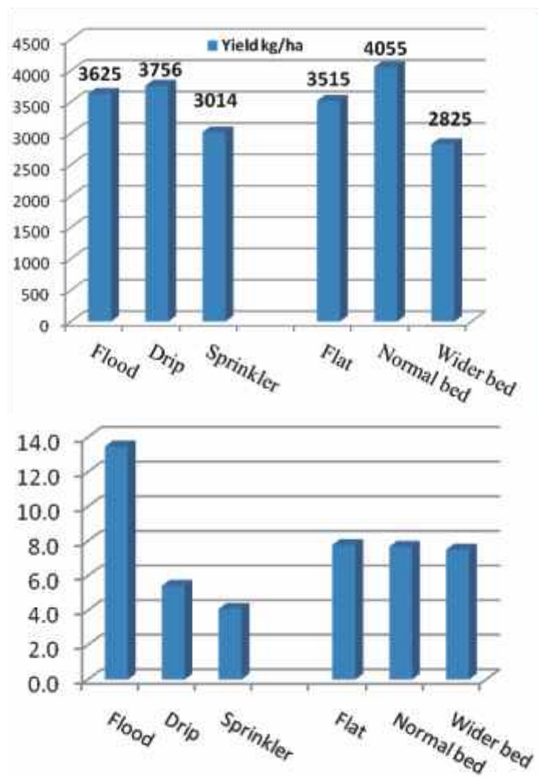


Fig. 9 Total irrigation water applied (ha cm) to maize for baby corn

Kasuri methi -maize (baby corn) cropping system

Irrigation with micro sprinkler in kassuri methi not only enhanced the yield by 24.7 and 26.4 %

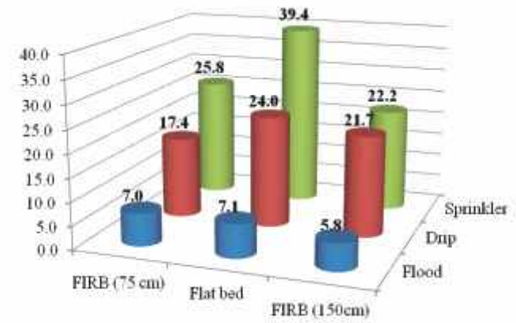
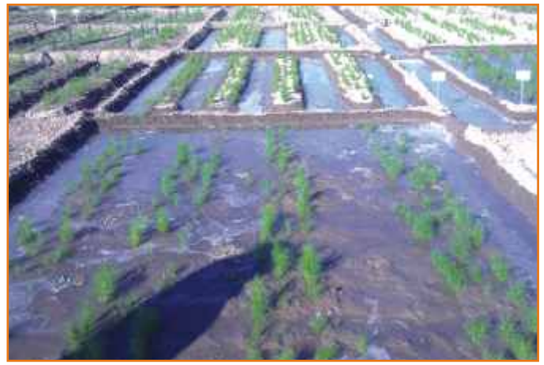


Fig 10 Water productivity (kg seed/ ha cm irrigation water) in kasuri methi as influenced by irrigation methods and land configuration

Irrigation techniques (Drip and micro sprinkler on raised beds (75 and 150 cm)



Land configuration (flat bed, raised bed having 75 and 150 cm)

Irrigation techniques in kasuri methi (Drip and micro sprinkler (75 and 150 cm)

(Table 5.9) but also improved the water productivity by 22.5 and 8.1 kg grain/ha cm irrigation water than flood and drip irrigation methods (Fig 10). 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). kasuri methi crop performance was better when sown on flat beds with micro sprinkler irrigation method.

Table 5.8 Effect of irrigation methods and land configuration on growth, yield attributes, water productivity and yield of cumin at harvest

Treatment	Plant height at harvest (cm)	Total water applied (ha cm)	Cumin yield kg/ha	water productivity kg grain/ ha cm irrigation water
Irrigation methods				
Flood	17.9	30.61	258.7	8.43
Drip	21.1	10.64	439.0	41.28
Micro Sprinkler	20.5	15.55	337.8	21.73
CD at %	2.9		58.6	12.3
Land Configuration				
Flat bed	19.6	19.62	274.6	18.26
Raised bed (75 cm)	19.9	17.68	479.4	33.39
Raised bed (150 cm)	20.0	19.49	281.5	19.78
CD at 5%	**NS**		**43.4**	**10.8**

Table 5.9 Effect of irrigation methods and land configuration on growth, yield attributes and yield of kasuri methi at harvest

Treatment	No of pod bunch/ plant	Seed yield kg/ha	Total water applied (ha cm)	Water productivity (kg seed /ha cm water)
Irrigation methods				
Flood	46.2	531.2	80.03	6.6
Drip	45.0	519.3	24.71	21.0
Sprinkler	58.1	706.2	24.24	29.1
CD at 5%	2.5	NS	4.5	2.7
Land Configuration				
Flat bed	49.7	715.0	44.20	16.2
FIRB (75 cm)	48.7	528.4	41.59	12.7
FIRB (150 cm) Wider bed	50.9	513.4	43.19	11.9
CD at 5%	**NS**	**NS**	**NS**	**2.3**

Table 5.10 Effect of Irrigation method and water conservation on yield and yield attributes of Nigella

Irrigation method	Branch/Pl	Capsule/Pl	Test Wt (gm)	Seed Wt/Pl(gm)	Yield (kg/ha)
I1-Flood	9.08	18.82	2.47	4.77	1582.83
I2-Drip	10.12	20.12	2.59	5.12	1744.66
I3- Low Pr Drip	8.40	18.22	2.33	4.50	1474.08
S Em±	**0.20**	**0.41**	**0.06**	**0.13**	**35.73**
CD at 5%	**0.78**	**1.61**	**0.25**	**0.50**	**140.26**
Cons. method					
P1- Mulching	9.60	20.58	2.59	5.31	1743.83
P2- Low Tunnel	9.27	19.31	2.49	4.91	1633.89
P3- Mul + L T	9.09	18.67	2.39	4.63	1566.87
P4-Control	8.84	17.64	2.38	4.34	1457.50
S Em±	**0.26**	**0.60**	**0.07**	**0.19**	**44.96**
CD at 5%	**0.77**	**1.79**	**0.20**	**0.57**	**133.57**

Scaling up Water Productivity in Seed Spices cultivation (Cumin and Nigella)

Application of irrigation through drip irrigation and conservation of moisture by mulching with 20 micron plastic sheet is better for realizing higher growth, yield and water use efficiency in Nigella. In case of Cumin, application of irrigation through low pressure drip irrigation and conservation of moisture by mulching with 20 micron plastic sheet is better for realizing higher growth, yield and water use efficiency.

Table 5.11 Effect of Irrigation method and water conservation on yield and yield attributes of Cumin

Irrigation method	Umbels/Pl	Umbellates/Pl	Seed Wt/Pl (gm)	Test Wt (gm)	Yield (kg/ha)
I1-Flood	4.23	32.75	4.23	3.52	180.53
I2-Drip	4.53	34.72	4.67	3.55	190.48
I3- Low Pr Drip	4.83	37.40	5.19	3.98	194.30
S Em±	**0.13**	**0.87**	**0.11**	**0.09**	**2.97**
CD at 5%	**0.50**	**3.42**	**0.43**	**0.37**	**11.68**
Conserv. method					
P1- Mulching	4.91	38.13	5.37	3.69	197.82
P2- Low Tunnel	4.62	35.93	4.85	3.62	192.44
P3- Mul + Low Tun	4.40	33.60	4.38	3.70	184.93
P4-Control	4.20	32.16	4.19	3.73	178.56
S Em±	**0.15**	**1.03**	**0.20**	**0.12**	**3.80**
CD at 5%	**0.46**	**3.05**	**0.59**	**0.35**	**19.56**

Experimental view for Nigella crop

Experimental view of cumin crop

Plate 1: Coriander growth in different protected structures at NRCSS Field

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

Among different protected structures, plastic walk in tunnel proves significantly better in terms of yield and its attributing characters. The plant height at harvest (119.20 cm), umbel per plant (55.0), umbellate per umbel (7.42) test weight (8.78 g) and seed yield (1533.71 kg/ha) were recorded in the said treatment. Whereas, under application of NPK fertilizers, economic seed yield (1454 kg/ha) with highest test weight was recorded with 80 per cent RDF. In interaction effects economic yield (1582.16 kg/ ha) of coriander was recorded in treatment combination containing plastic walk in tunnel with 80% RDF (Table 5.12).

Table 5.12 Effect of protected structures and fertilizer doses (P x N) mean Interaction table in coriander

	Plastic walk in tunnel	Green net (60%)	Control (Open condition)	Mean
40% RDF (N:P:K., 24:12:04 kg/ha)	1454.78	1345.46	1312.40	1370.88
60% RDF (N:P:K., 36:18:06 kg/ha)	1509.25	1401.58	1339.77	1416.867
80% RDF (N:P:K., 48:24:08 kg/ha)	1582.16	1411.00	1371.22	1454.793
100% RDF (N:P:K., 60:30:10 kg/ha)	1588.67	1427.67	1369.99	1462.11
Mean	1533.67	1396.428	1348.345	
	P	**N**	**PxN**	
S.Em±	**11.60**	**11.69**	**20.25**	
CD at 5%	**45.56**	**34.73**	**60.16**	

Table 5.13 Effect of protected structures and fertilizer doses (P x N) mean interaction table in cumin

	Insect proof net (20% Mesh)	Black net (50%)	Control (Open condition)	Mean
40% RDF (N:P:K., 12:08:08 kg/ha)	736.88	700.94	622.18	686.66
60% RDF (N:P:K., 18:12:12 kg/ha)	759.23	729.93	664.20	717.78
80% RDF (N:P:K., 24:16:16 kg/ha)	832.25	737.95	673.86	748.02
100% RDF (N:P:K., 30:20:20 kg/ha)	898.77	743.30	721.39	787.82
Mean	806.78	728.03	670.40	
	P	**N**	**PxN**	
S.Em±	**5.04**	**3.99**	**6.91**	
CD5%	**19.77**	**11.86**	**20.54**	

Minimum aphid population (20.1) was recorded in the month of January in the plastic walk in tunnel as compared to all other treatments.

Effect of different protected structures and fertilizer doses on growth and yield of cumin.

Insect proof net exhibited significantly higher values of plant height at harvest (28 .73 cm), umbels per plant (12.83), seeds per umbellate (6.08), test weight (3.66 g) and seed yield (806.78 kg/ha) as compared to black net and open field in cumin. Similarly under application of NPK fertilizers, 100 per cent RDF exhibited maximum plant height at harvest (29.18 cm), seeds per umbellate (6.67), test weight (3.87 g) and seed yield (787.82 kg/ha). In interaction effects maximum yield (898.78 kg/ ha) of cumin was recorded in treatment combination containing insect proof net with 100 % RDF. Minimum aphid population (7.37) in the month of January was also recorded in the insect proof net as compared to all other treatments (Table 5.13).

5.2.3 Assessment of edaphic stresses and nutrient management for sustainable seed spices

Nutrient Influx Efficiency in *Coriandrum sativum*, *Cuminum cyminum, Foeniculum vulgare* and *Trigonella foenum-graecum* cultivars

Cumin genotypes differed in nutrient influx efficiency depending upon their growth stages.N, P, K, Mn, Zn and Cu influx rate was highest in GC-4 at 40 days while at 90 days it was highest in AC-167. However, Fe influx was highest in GC-4 at all the stages.In fennel N, P, K and Mn influx rate up to 45 days was highest in genotype RF-101 while Cu, Fe and Zn influx rate at 45 days was higher in AF1-87. Nutrient influx rate in fenugreek cultivars Rajendra kranti and UM-35 was highest up to 35-40 days. However, at the age of 75-80 days nutrient influx efficiency was highest in RMt-305 (Fig. 11 & 12).

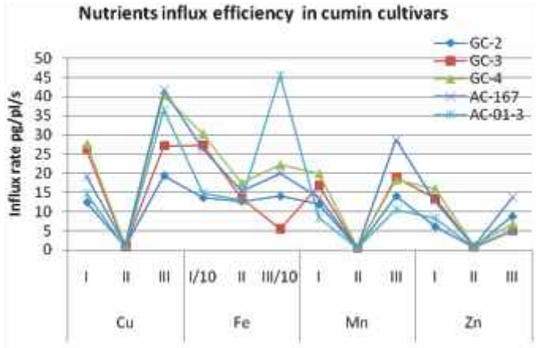


Fig. 11 Micronutrients influx rate in cumin cultivars

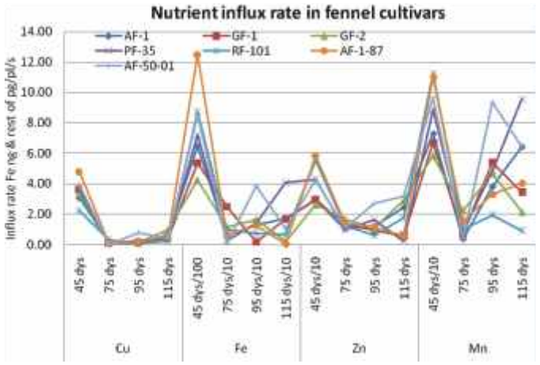


Fig. 12 Micronutrients influx rate in fennel cultivars

Nutrient uptake by coriander, cumin, fennel, fenugreek and anise with various IW:CPE ratio.

Nitrogen, phosphorus, potassium and Zn uptake was highest in coriander with IW:CPE ratio 0.6 and least with 0.4 IW:CPE ratio (Fig. 13). Copper uptake was highest with IW:CPE ratio 1.2. However, iron and Mn uptake was higher with IW:CPE ratio 1.0. N and P uptake in fennel was highest with IW:CPE ratio 0.8. Fennel removed highest K with IW:CPE ratio 1.2. Cu uptake increased with increase in IW: CPE ratio. While, Mn uptake increased up to 0.8 IW:CPE ratio. NPK and micronutrient uptake in fenugreek increased with increase in IW:CPE ratio (Fig 14 & 15). N, K, Zn and Cu uptake in anise increased with increase in IW:CPE ratio up to 1.0, whereas P uptake increased up to 0.8 (Fig. 16). Fe uptake was highest with IWCPE ratio 0.8 and 1.0.

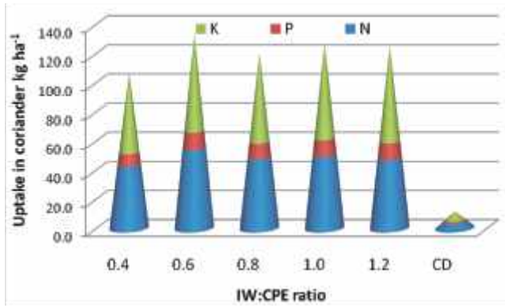


Fig. 13 Influence of water input on macronutrients uptake by coriander

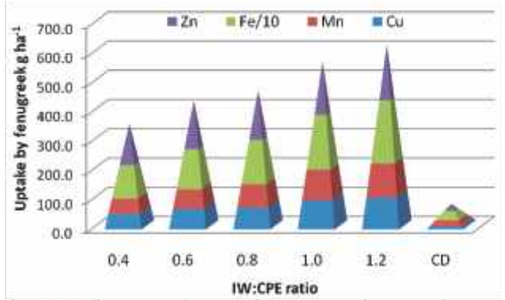


Fig. 14 Influence of water input on micronutrients uptake by fenugreek

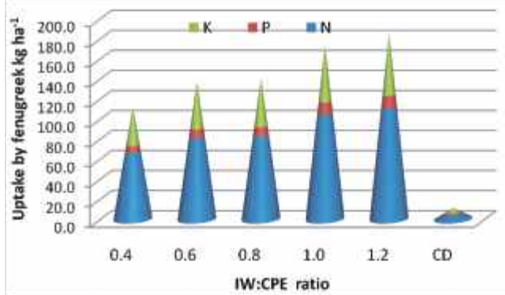


Fig. 15 Influence of water input on macronutrients uptake by fenugreek.

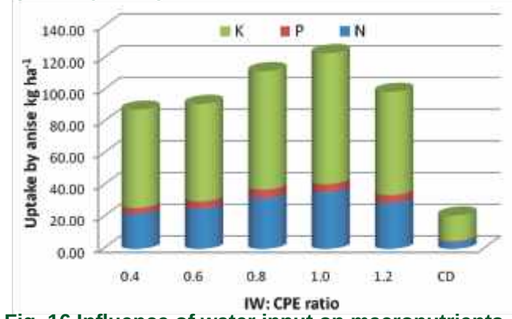


Fig. 16 Influence of water input on macronutrients uptake by anise.

Evaluation of seed spices crops against problematic soil and water situations

Seed germination study in seed spices cultivars/genotypes with salinity

Seed germination of dill improved by the salinity up to EC 4 dSm^{-1} and reduced thereafter (Fig. 17). Nigella germination percentage was reduced with increase in salinity (Fig. 18). However, significant reduction was observed with 8.0 EC and beyond that level.

Performance of seed spices under limed acid soils of Eastern Plateau Hill regions.

There was no statistical variation observed under limed and non-limed soil. It indicates that coriander has tolerance to soil acidity. However, fenugreek yield increased with increase in lime doses and was significantly higher with 50 per cent dose of lime and beyond that. Moreover, yield was lower in acid soil than the neutral to higher pH, whereas coriander performed better in acid soils than the neutral to alkaline soils.

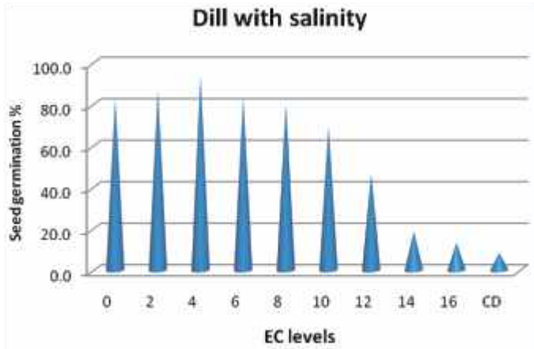


Fig. 17 Influence of salinity on seed germination of dill.

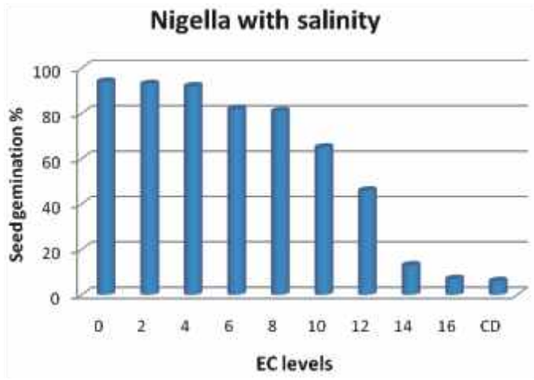


Fig. 18 Influence of salinity on seed germination of nigella.

5.2.4 Microbiological approaches in integrated nutrient management in seed spices

Screening of plant growth promoting rhizobacteria for coriander (*Coriandrum sativum*)

Twenty five coriander plant soil samples have been collected from Ajmer, Baran, Jhalawar and Kota Districts of Rajasthan for isolation of rhizospheric bacteria. These samples have been analysed for their electrical conductance (EC), pH, total viable bacterial count, and total viable fungal count. Microbial count on nitrogen free Azotobacter medium, Pikovskaya medium containing Tricalcium Phosphate and Kings B medium have also been done for prospective microbial analysis of soil samples. Total thirty six cultures were isolated and screened for IAA production, acid production and capacity to solubilise the Tricalcium phosphate. Fourteen bacterial cultures were found superior w.r.t. IAA production (Fig.19) and these were further screened for their biochemical characteristics to utilize different sources of carbohydrates and production of the specific enzymes.

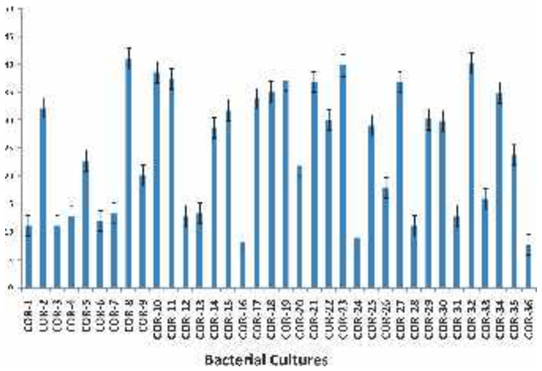


Fig. 19 IAA production by bacterial isolates from coriander rhizoshere

Isolation and Evaluation of phosphate solubilising microorganisms (PSM) 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 and further screened on National Botanical Research Institutes Phosphate (NBRIP) medium. Maximum Phosphate solubilization in broth assay was observed in bacterial isolates FEN-14(51.66 µg/ml) which was at par with FEN-1(51.30 µg/ml) and FEN-5 (50.68 µg/ml) as given in Table 5.14. These isolates were further screened for tolerance to various abiotic stresses such as pH, high temperature and salinity.

5.2.5 Post Harvest management and value addition in Seed Spices

Standardization of harvest and post harvest processing and value addition through CAP/MAP of Seed Spices Crops

Harvesting indices: In fennel, test weight of the grain was increased with the time and was found maximum (4.06 g) after 204 days of sowing. However, after organoleptic evaluation it was noticed that test, colour and aroma was attractive in fennel grain at 181 DAS. At this harvesting stage, maximum recovery (42.97%) was recorded (Table 5.15).

Table 5.14 Screening of selected bacterial isolates for Tricalcium Phosphate solubilisation

Bacterial isolates	Phosphate Solubilization zone on agar plates (mm)	Phosphate solubilization in broth assay (µg/ml)
FEN-1	1.25	51.30
FEN-2	1.56	34.82
FEN-3	2.03	18.86
FEN-4	2.12	23.92
FEN-5	1.28	50.68
FEN-6	1.55	22.77
FEN-7	2.00	38.04
FEN-8	2.33	30.62
FEN-9	1.88	31.67
FEN-10	1.20	27.92
FEN-11	1.26	47.26
FEN-12	1.65	25.94
FEN-13	1.44	38.21
FEN-14	1.62	51.66
FEN-15	1.27	41.13
FEN-16	1.40	15.83
SEm	0.27	1.07
CD 0.05	0.51	2.90

Table 5.15 Harvesting indices for green fennel

Days of harvesting in fennel	Taste (marks out of 10)	Colour (marks out of 10)	Moisture content (%)	Recovery (%)	Test wt (g)
174 DAS	6	6	65.67	34.33	3.60
181 DAS	**9**	**9**	**57.03**	**42.97**	**3.75**
189 DAS	8	8	62.8	37.2	3.84
196 DAS	6.5	6.5	60.4	39.6	3.95
204 DAS	7	7	63.93	36.07	4.06

Table 5.16 Effect of different drying methods on green fennel grain

Method of drying	Taste (marks out of 10)	Colour (marks out of 10)	Moisture content (%)	Recovery (%)	Test weight (g)
Shade drying (23-30°C) 51 hrs	6.7	6.5	65.16	34.45	4.62
Sun drying (28-37°C) 48hrs	7.2	6.0	63.50	35.36	4.85
Solar drying (40-47°C) 33 hrs	**9.3**	**9.2**	**61.30**	**39.82**	**5.17**
Vegetable dryer (50°C) 30 hrs	8.2	7.8	64.50	33.80	4.85
Multipurpose grain dryer (60°C) 27hrs	7.5	7.5	66.8	33.25	4.45

Table 5.17 Physical properties of Fennel and cumin

Seed	Test weight (g)		Bulk density g/cc		Seed size			
					L (mm)		W (mm)	
	Mean	SEm±	Mean	SEm±	Mean	SEm±	Mean	SEm±
Fennel	5.09	±0.259	0.323	±0.008	6.95	±0.107	2.40	±0.041
Cumin	4.31	±0.179	0.347	±0.001	5.81	±0.053	1.56	±0.014

Table 5.18 Effect of different packaging material on different parameters of fennel after 8 months of storage

Treatment	Moisture content (%)	Damaged seed count (%)	Seed viability (%)	Adult insect count
Aluminum Bag	**7.52**	**4**	**89.2**	**8**
Polybag (200 gauge)	7.86	6	76.8	15.4
Polybag (100 gauge)	8.02	7.4	76.2	10.2
Cloth Bag	8.64	15	64.6	28.6
Jute Bag	8.98	17.4	53.8	37
Paper Bag	9.04	18	48.6	45.6
S.Em±	**0.149**	**0.98**	**1.72**	**3.75**
CD at 5%	**0.435**	**2.85**	**5.01**	**10.95**

Table 5.19 Effect of different packaging material on different parameters of cumin after 8 months of storage.

Treatment	Moisture content (%)	Damaged seed count (%)	Seed viability (%)	Adult insect count
Aluminum Bag	**7.28**	**6.2**	**89.6**	**5.6**
Polybag (200 gauge)	7.66	9.2	81	12.2
Polybag (100 gauge)	7.74	13.2	79	13
Cloth Bag	8.7	16	69.8	22.2
Jute Bag	8.86	17.8	63.8	28.8
Paper Bag	8.94	17.4	66.8	25.4
S.Em±	**0.11**	**1.93**	**1.8**	**4.35**
CD at 5%	**0.33**	**5.63**	**5.25**	**12.697**

Standardization of the drying techniques

In fennel five methods of grain drying were employed viz., shade dryer (30°C), sun dryer (35°C to 37°C), solar dryer (40°C to 42°C), vegetable dryer (50°C) and multipurpose grain dryer (60°C). Fennel grains which were dried under solar dryer, gave maximum test weight (5.17 gm), recovery (39.82 %) with lowest moisture content (61.30%) and highest taste marks (9.3) and colour marks (9.2) (Table 5.16)

Packaging and storage

Aluminum bag vacuum packaging was proved to be the best as compared to other packaging methods for all the parameters studied in both Fennel and cumin after 8 months of storage. (Table 5.17, 5.18 & 5.19)

5.3 Crop Protection

5.3.1 Survey and surveillance of diseases of seed spices

On-farm survey of seed spice diseases

Field survey was conducted during *rabi* season from 2007-08 to 2011-12 in different districts of Rajasthan, Gujarat and U.P. Occurrence and prevalence of diseases of seed spices were recorded.

Cumin disease

The state and district wise distribution of cumin diseases on farmer's field are given in table

Table 5.20 Distribution of cumin diseases in different districts of Rajasthan and Gujarat surveyed during 2007-08 to 2011-12

State/District	Villages/ location	Fields	Cultivars grown	Diseases identified
Rajasthan				
Ajmer	15	43	GC 4, RZ 19, Own seed	Wilt, Blight, Powdery mildew, yellowing symptoms
Nagaur	15	22	RZ 19, Avani–111, Dinkar, Chamatkar, We stern C-60, Own seed	Wilt, Blight, Powdery mildew, *Orobanche* , yellowing symptoms
Jodhpur	15	35	Western C-60, unknown, DSPL Heera No.1, Avani-111, Sona-1,Sardar Utsav-44	Wilt, Blight, Powdery mildew, yellowing symptoms
Jaisalmer	11	26	Own seed, Avani-111	Wilt, Blight
Barmer	14	52	GC 4, Western seed, Own seed	Wilt, Blight, Phyllody
Jalore	15	17	GC-4, Avani 111, Western C -60, RZ 223, local own seed	Wilt, Blight, Phyllody
Pali	7	8	unknown, Avani-111	Wilt, Blight, Powdery mildew, yellowing symptoms
Gujarat				
Banaskantha	7	7	GC 4	Blight, Powdery mildew
Patan	2	7	GC 4, Ganesh 55	Wilt, Blight

Table 5.21 Prevalence of major coriander diseases in different districts of Rajasthan, Gujarat and Uttar Pradesh

State	District	Villages	Fields	Stem gall (%) Mean	Stem gall (%) Range	Powdery mildew (%) Mean	Powdery mildew (%) Range
Rajasthan	Ajmer	1	4	-	-	39.7	10-90
	Baran	2	3	34.7	27-50	-	-
Gujarat	Banaskantha	1	2	-	-	34.0	0-34
U.P.	Faizabad	15	17	41.9	10-92.5	42.5	5-90
	Lucknow	2	2	32.5	31.3-33.8	-	-
	Barabanki	1	3	42.9	41.3-46.3	15.0	0-15

5.20. The major cumin diseases observed on farmer's field were wilt (0-60%), blight (0-80%), and powdery mildew (0-54%) in moderate to severe form. Other diseases like yellowing, phyllody and parasitic plant *Orobanche* were seen as emerging problems in cumin. Wilt and blight diseases were wide spread as they occurred in Ajmer, Nagaur, Barmer, Jalore, Jodhpur, Jaisalmer, Pali, districts of Rajasthan while Banaskantha and Patan districts of Gujarat. Appearance of powdery mildew was observed in both the states in few districts. Phyllody was observed in Barmer & Jalore districts in traces. Few fields were also infested with parasitic plant Orobanche in Nagaur and Jodhpur districts of Rajasthan.

Coriander diseases

The major coriander diseases observed on farmer's field were stem gall, blight, and powdery mildew in moderate to severe form. Stem gall caused by *Protomyces macrosporus* was wide spread and occurred in Baran district of Rajasthan and Faizabad, Lucknow and Barabanki district of U.P. Appearance of powdery mildew was observed in both the states in few districts.

Table 5.22 Prevalence of major fennel diseases during the *rabi* season of 2009-10 to 2011-12

District	Villages	Fields	Blight Mean	Blight Range	Powdery mildew Mean	Powdery mildew Range
Ajmer	1	4	-	-	6.0	0.0-20.0
Sirohi	5	8	28.0	20-30	-	-
Jodhpur	1	8	-	-	-	-
Banaskantha	11	16	34.7	2-70	35.8	25.0-70.0
Faizabad	8	8			62.0	18.8-95.0

Table 5.23 Prevalence of major diseases of fenugreek during *rabi* season of 2009-10 to 2011-12

District	Locations	Fields	Powdery mildew Mean	Powdery mildew Range	Downy mildew Mean	Downy mildew Range	Leaf spot Mean	Leaf spot Range
Jodhpur	1	1	Nil	-	Nil	-	Nil	-
Nagaur	2	7	24.3	0-45	-	-	-	-
Ajmer	1	4	46.0	30-90	36.0	25-70	Traces	-
Faizabad	9	10	31.0	2.5-96.3	-	-	52.5	

Fennel and fenugreek diseases

Major fennel diseases observed on farmer's field were blight, powdery mildew and gummosis in moderate to severe form in Sirohi district of Rajasthan, Banaskantha district of Gujarat and Faizabad district of U.P. The major fenugreek diseases observed on farmer's field were powdery mildew, downy mildew, leaf spot and root rot in Ajmer and Nagaur districts of Rajasthan and Faizabad district of U.P.

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

The maximum Percent Disease Index (PDI-32.0) was found in the treatment (T10) with no soil solarization. The minimum Percent Disease Index (PDI-6.0) was found in the treatment 'T8' (20 days soil solarization + neem cake + *Trichoderma viride*) followed by treatment 'T9' (30 days soil solarization + neem cake + *Trichoderma virede*) with PDI-6.5. Similarly, the maximum yield (173 gm/plot) was found in the treatment 'T8' followed by in the treatment 'T9' with (168 gm/plot). The minimum yield was recorded in the treatment T10 (control) with 60 gm/plot.

Table 5.24 Percent disease index and reduced percent of wilt disease in cumin

Treatment	Mean Percent Disease Index (PDI)		% reduction in disease
T1	15.7	(23.34)	50.94
T2	14.0	(21.17)	56.25
T3	13.0	(21.13)	59.38
T4	11.5	(19.82)	64.07
T5	9.5	(17.95)	70.32
T6	9.4	(17.85	70.63
T7	8.6	(17.05)	73.13
T8	6.0	(14.17)	81.7
T9	6.5	(14.77)	79.29
T10	32.0	(34.45)	0
T11	26.0	(30.65)	18.75
CD at (0.05)		**0.84**	
CD at (0.01)		**0.22**	

*Data within parenthesis are arcsin transformed value

Isolation, purification and maintenance of cultures

The diseased samples were collected and causal pathogens were isolated, purified and identified. The identity was confirmed from ITCC as

Pathogens isolated and purified from diseased samples

Fusarium oxysporum, *F. solani*, *Alternaria alternata* and *A. burnsii*.

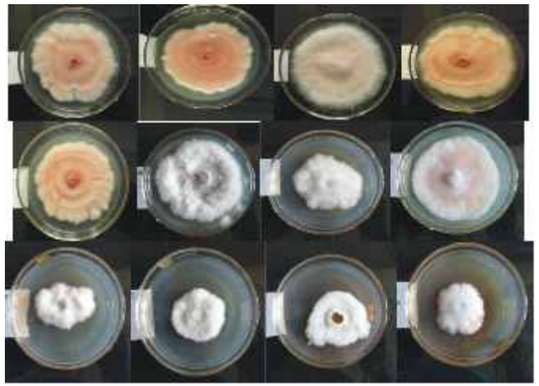
Cumin wilt infected plants were collected from different geographical regions covering states of Rajasthan and Gujarat. The pathogen *F. oxysporum* was isolated from cumin roots and purified. The different isolated showed variation in cultural characteristics and sporulation on potato dextrose medium.

Monitoring diseases of seed spices on the Institute farm

Seed spices crops were sown on four different dates during *rabi* 2008-09 to 2011-12 at NRCSS farm to monitor the appearance and spread of diseases. In cumin, wilt disease was observed from early crop stage while blight appeared during the month of December-January at pre flowering to flowering stages. Powdery mildew appeared at the maturity stage of the crop.

In fenugreek powdery mildew disease was observed in the month of January-February and spread up to maturity of the crop. The root rot of fenugreek was observed in early growth stage.

In coriander and dill, powdery mildew symptoms were observed late in the season during



Morphological variation in Fusarium isolates isolated from wilt infected roots

February-March and spread occurred within a week after initiation.

Observations for meteorological factors (max. and min. temperature, RH, rainfall) were collected from NRCSS observatory for analyzing the correlation of environmental factors with the spread of powdery mildew of coriander and fenugreek and blight disease of cumin during the crop season.

Coriander Powdery Mildew

The mean maximum and minimum temperature favoured for disease development were

Table 5.25 Correlation among coriander powdery mildew PDI and meteorological data

Date of sowing	Max_Temp			Min_Temp			RH_Max			RH_Min	
	09-10	10-11	11-12	09-10	10-11	11-12	09-10	10-11	11-12	10-11	11-12
D1	0.76	0.50	0.91	0.75	0.73	0.85	-0.64	-0.75	-0.10	-0.89	0.12
D2	0.84	0.55	0.91	0.82	0.79	0.86	-0.72	-0.73	-0.10	-0.88	0.12
D3	0.80	0.74	0.90	0.79	0.88	0.84	-0.69	-0.83	-0.14	-0.90	0.11
D4	0.76	0.79	0.88	0.76	0.91	0.83	-0.67	-0.85	-0.10	-0.91	0.16

Table 5.26 Correlation among fenugreek powdery mildew PDI and meteorological data

Date of sowing	Max_Temp			Min_Temp			RH_Max			RH_Min	
	09-10	10-11	11-12	09-10	10-11	11-12	09-10	10-11	11-12	10-11	11-12
D1	0.910	0.674	0.751	0.926	0.821	0.952	-0.827	-0.747	-0.373	-0.709	-0.190
D2	0.894	0.656	0.725	0.901	0.795	0.983	-0.794	-0.766	-0.383	-0.721	-0.153
D3	0.788	0.626	0.750	0.753	0.747	0.917	-0.607	-0.760	-0.331	-0.715	-0.122
D4	0.775	0.626	0.892	0.776	0.685	0.652	-0.609	-0.762	-0.490	-0.714	-0.259

27.9 and 14.2°C during 2010-11 and 23.8 and 9.3°C during 2011-12. Powdery mildew had positive correlation with minimum and maximum temperature (Table 5.25).

Fenugreek Powdery Mildew

The mean maximum and minimum temperature favoured for disease development were 25.1 and 11.1°C during 2010-11 and 22.7 and 7.2°C during 2011-12. The powdery mildew was positively correlated with minimum and maximum temperature (Table 5.26).

Cumin Blight

The mean maximum and minimum temperature favoured for disease development were 24.6 and 10.5°C during 2010-11 and 22.7 and 6.9°C during 2011-12, whereas maximum relative humidity was 60.8 and 56.5 during 2010-11 and 2011-12 respectively. The blight disease was positively correlated with relative humidity (Table 5.27).

Development of plant protection schedule for cumin cultivation

Field experiments were conducted during *rabi* seasons of 2009-10 and 2010-11 with cumin varieties RZ 209 and GC 4 to evaluate four disease and pest management schedules. The schedule I (S1) comprised of recommended disease and pest management practices and Schedule IV (S4) comprised of organic treatments, whereas, Schedule II (S2) and Schedule III (S3) included new chemical molecules.

The overall results revealed that schedule II [Soil application of neem cake + mustard cake@ 0.5 t / ha, Seed treatment with tebucanazole @ 2.5 g/ kg, Soil drenching with metalaxyl (0.1%) at 25-30 DAS, foliar spray with mancozeb (0.2%) at 60 DAS and propiconazole (0.1%) at 75 and 90 DAS, foliar spray with karathane (0.1%) at 70, 85 and 100 DAS, FS acetamiprid 0.005% 60-70 DAS and imidachlorpid 0.005% 70-80 DAS] reduced diseases PDI and insect population (Fig 20 & 21) over untreated control, schedule I (S1), schedule III (S3), and schedule IV (S4).

The residue analysis in seeds revealed that except mancozeb other pesticides residues i.e. karathane, acetamiprid, imidachloprid, dimethoate and carbosulfan were below detection limit (BDL) (Table 5.28).

It is conclusively proved that cumin diseases and insects can be managed successfully and yield can be increased by adopting proper schedule involving soil application of oil cakes, seed treatment and foliar application of newer fungicide and insecticide molecules.

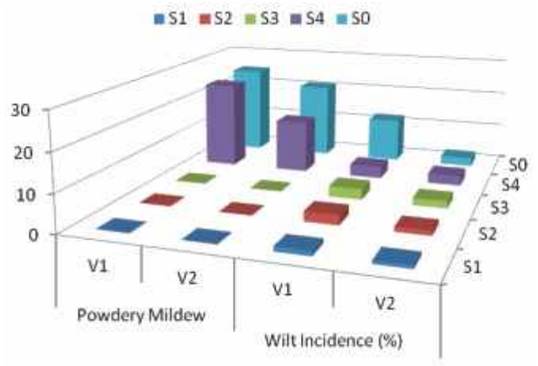


Fig. 20 Effect of application schedules on powdery mildew and wilt of cumin

Table 5.27 Correlation among cumin blight PDI and meteorological data

Date of sowing	Temperature				Relative Humidity			
	Maximum		Minimum		Maximum		Minimum	
	10-11	11-12	10-11	11-12	10-11	11-12	10-11	11-12
D1	-0.814	-0.655	-0.807	-0.707	0.774	0.844	0.918	0.392
D2	-0.806	-0.618	-0.820	-0.743	0.776	0.864	0.905	0.413
D3	-0.803	-0.593	-0.826	0.176	0.767	-0.299	0.826	-0.318
D4	-0.817	-0.507	-0.781	0.289	0.774	-0.405	0.870	-0.356

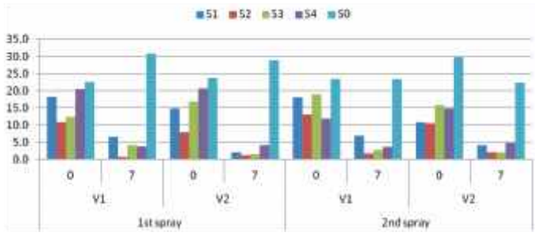


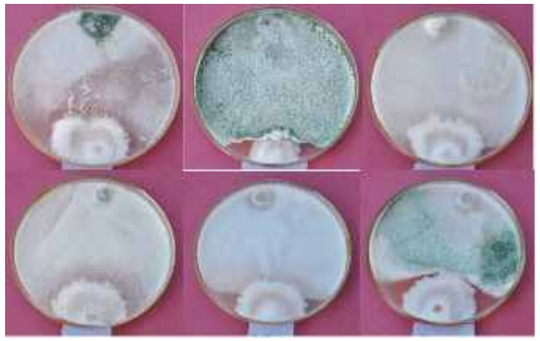
Fig. 21 Effect of application schedules on aphid population on cumin (mean of two years)

Table 5.28 Residue analysis of insecticides and fungicides in cumin seed after harvest

Treatment	Pesticide	Residue (µg/g)			
		R1	R2	R3	Mean
S2	Mancozeb	1.936	2.112	1.995	2.014
	Karathane	BDL	BDL	BDL	BDL
	Acetamiprid	BDL	BDL	BDL	BDL
	Imidachloprid	BDL	BDL	BDL	BDL
S3	Mancozeb	1.9	1.8	1.9	1.9
	Karathane	BDL	BDL	BDL	BDL
	Dimethoate	BDL	BDL	BDL	BDL
	Carbosulfan	BDL	BDL	BDL	BDL
S0		ND	ND	ND	ND

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

The native *Trichoderma spp.* isolated from cumin rhizosphere showed variable reaction in colony growth, sporulation, production of volatile and non volatile inhibitors. The isolates CuTk 7-01, CuTa 7-02, CuTh 9-02 and CuTh 3-03 showed more than 40% growth inhibition against cumin wilt and nigella



Bioefficacy of Trichoderma isolates against wilt pathogens of cumin

root rot pathogens in dual culture under *in vitro* conditions.

Efficacy of picoxystrobin 25 SC on cumin blight caused by *Alternaria burnsii*

Picoxystrobin 25 SC, was applied as foliar spray after initiation of disease at 12 days interval in different concentrations along with mancozeb (0.2%) and azoxystrobin (0.1%). The results revealed that all treatments reduced blight disease as compared to untreated control. Picoxystrobin was found effective for blight management even at lower doses; however, there was more reduction in disease with the increase in fungicide concentration. Maximum blight was reduced in the plots treated with picoxystrobin (0.12%) followed by picoxystrobin (0.1%) and azoxystrobin (0.1%). No phyto-toxicity symptoms were observed when picoxystrobin was sprayed up to 4 ml/lit, which permit the use of picoxystrobin on the cumin plants even at higher concentration.

Table 5.29 Efficacy of Picoxystrobin against cumin blight (Pooled)

Treatment	Cumin blight PDI	Percent Disease Control	Yield (Kg/ha)
Picoxystrobin 25SC (0.06%)	20.8 (4.7)	29.1	282
Picoxystrobin 25SC (0.08%)	17.2 (4.3)	41.4	307
Picoxystrobin 25SC (0.1%)	11.0 (3.5)	62.5	366
Picoxystrobin 25SC (0.12%)	10.2 (3.3)	65.3	391
Azoxystrobin 25SC (0.1%)	11.8 (3.6)	59.6	368
Mancozeb (0.2%)	16.7 (4.2)	43.1	267
Untreated Control	29.3 (5.5)	-	216
CD (0.05)	2.27 (0.28)		79.0

Figures in parenthesis are transformed value

5.3.2 Survey and Surveillance of insect pests in seed spices

Sucking pests comprises the major pests complex of seed spice crops. Major sucking pests associated with these crops were aphids, jassids, white fly, leaf minor, thrips, hoppers and bugs and are found on crop from early stage to seed formation/maturation stage. Seed wasp infested started from full vegetative growth to seed maturation stages. Defoliator like *Helicoverpa armigera* and *Spodoptera litura* were found at seed formation /podding stages. Among predators *Coccinella septumpunctata* was found as major predator on all the crops. Besides syrphid fly, *Chrysoperla carnea* is also found in less frequency. *Aphidius spp* was the major parasitoides of aphids found on all seed spices. Fennel and cumin crop attracted higher number of natural enemies than other crop.

Biorational Management of aphids in cumin and fennel crops

Different biorational products *viz.*, entomopathogen (*Beauveria bassiana, Metarhizium anisopliae and Verticillium lacanii*), and neem oil alone and in combination with entomopathogen, *Coccinella septempunctata* (predator) and a standard insecticide were tested for control of aphids *Myzus persicae* and Apis *gossypii* in cumin and fennel crop. In cumin field level colonization of *V. lecanii* was found higher than other entomopathogen and gave maximum control for both the species of aphids. Among plant products neem oil, allyl–iso–thio cyanate and sulphur extract of Karanj gave good control. Overall, insecticidal check gave maximum protection but all other treatments were significantly superior over the control in term of pest control and seed yield. In fennel crop similar trend was observed.

Table 5.30 Effect of different treatments on yield of cumin at harvest.

Treatments	2009-10	2010-11	2011-12	Average
T1 *Beaveria bassiana*	4.66	4.42	4.31	4.46
T2 *Metarhizium anisopliae*	4.85	4.49	5.50	4.95
T3 (V.I.) *Verticillium lecnai*	5.10	4.95	6.32	5.46
T4 Neem oil-2%	5.34	4.90	6.62	5.62
T5 (T1+T4)	3.90	3.38	4.21	3.83
T6 (T2+T4)	3.60	3.57	5.39	4.19
T7 (T3+T4)	4.20	3.89	5.45	4.51
T8 Release of *Coccinella septempunctata* L.	3.30	3.10	3.61	3.34
T9 Deltamethrin 0.005%	5.90	5.72	7.53	6.38
T10 Allyl–iso–thio cynate -1%	4.90	4.32	7.00	5.41
T11 Sulphur compound of Karanj extract -1%	4.70	4.46	6.70	5.29
T12 Control	1.63	2.58	2.12	2.11

Entomopathogen developed on aphids body

5.4 Basic Science

5.4.1 Physiological parameters and their relation to seed yield in major seed spices crops

Fenugreek (*Trigonella foenum-graecum*):

Ratio of shoot to root weight, shoot to root length and fresh to dry weight showed no direct relation with seed yield in fenugreek, however more shoot length and number of branches were recorded in the genotype giving higher yield. Both genotypes differ in the correlation between growth parameters and seed yield. Correlations at 45, 60 and 90 DAS were found non significant while at 120 DAS strong positive correlation between some growth parameters and yield was observed in both the genotypes. Ratio of FWt/DWt and SWt/RWt was

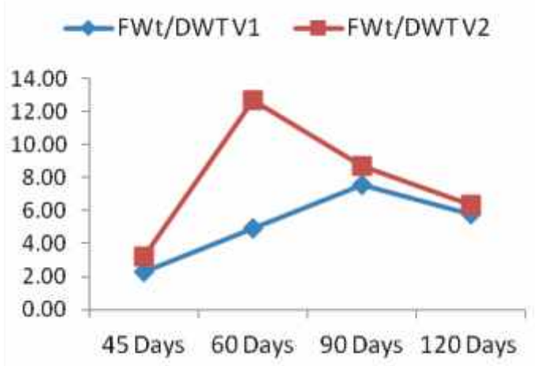


Fig. 22 Temporal variation in growth parameters of fenugreek

Fig. 23 Temporal variation in growth parameters of fenugreek

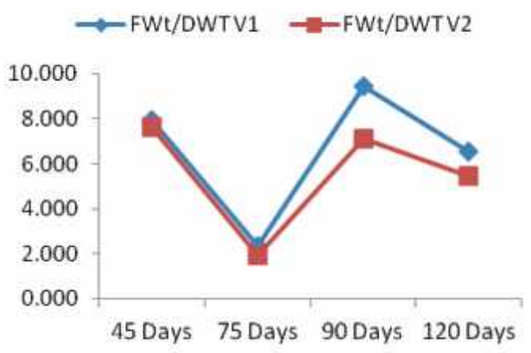
negatively correlated with seed yield in genotype AM 1 but not in RMT 305. Chlorophyll a, b and total chlorophyll was more in genotype RMT 305 at 75 and 90 DAS. A slight negative turgor was observed in genotype RMT 305 at flowering stage

Coriander (*Coriandrum sativum* L.)

In coriander ratio of shoot to root weight, shoot to root length and fresh to dry weight showed direct effect on seed yield per plant i.e. less ratio give higher yield. Except number of branches all parameters showed increase with growth stages. Growth pattern was similar in both genotypes, however, SWt/RWt ratio was different at 90 and 120 DAS. In RCr 41 except shoot and root length all other parameters were positively correlated with yield. This correlation was also reflected at 45 and 60 DAS. Total

Table 5.31 Growth parameters and their correlation with seed yield in fenugreek

	Seed Yield/plant (g)							
	45 DAS		60 DAS		90 DAS		120 DAS	
	RMT 305	AM 1	RMT 305	AM 1	RMT 305	AM 1	RMT 305	AM 1
FWt	0.241	0.301	-0.033	0.036	-0.395	-0.393	0.669	0.835
RWt	-0.152	0.289	-0.123	0.512	-0.410	0.197	0.502	0.845
SWt	0.254	0.286	-0.034	0.437	-0.580	-0.441	0.378	0.635
NuB	0.273	-0.027	-0.156	0.188	-0.298	-0.177	0.694	0.792
Rlen	0.363	0.469	0.102	0.023	-0.144	-0.382	-0.247	0.282
Slen	0.136	-0.003	0.292	-0.054	0.100	-0.519	-0.040	0.670
DWt	0.275	-0.093	-0.307	-0.358	-0.187	-0.339	0.306	0.830
FWt/DWt	-0.2847	0.774	0.3440	0.512	-0.4190	-0.034	0.6100	-0.695
SWt/RWt	0.4270	-0.034	0.1413	0.081	-0.3671	-0.313	0.0882	-0.342
Slen/Rlen	-0.3407	-0.484	0.1648	-0.056	0.1820	-0.173	0.1589	0.569



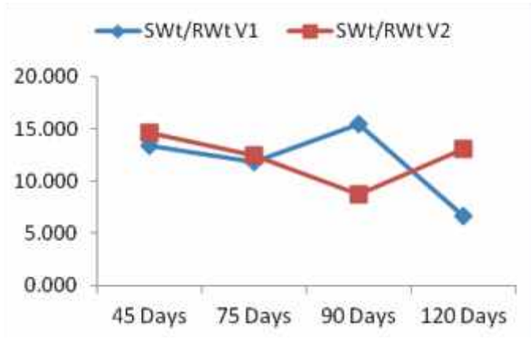


Fig. 23 Temporal variation in growth parameters of coriander

chlorophyll content was more in RCr 41at 75 DAS and in ACr 1 at 100 DAS. Genotype ACr 1 showed more turgor pressure at both flowering and post flowering stages.

Fennel (*Foeniculum vulgare* M.)

In fennel up to harvest stage no significant difference was observed in both genotypes. More shoot to root length ratio resulted in higher yield in fennel. Less ratio of shoot to root weight and fresh to dry weight resulted in higher yield. All growth

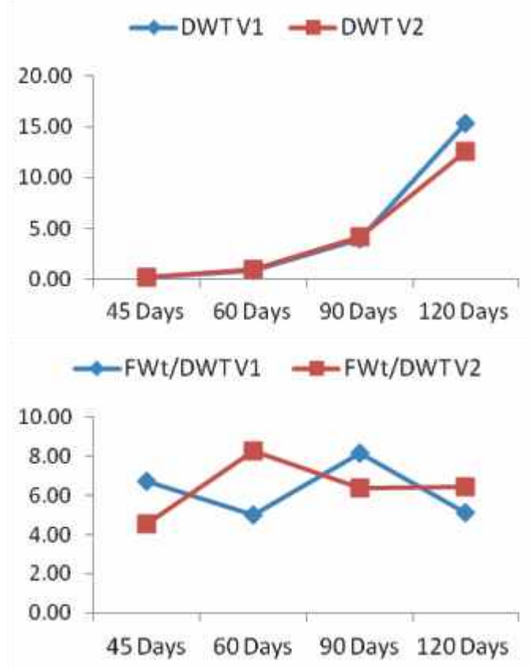


Fig. 24 Temporal variation in growth parameters of fennel

Table 5.32 Growth parameters and their correlation with seed yield in coriander

	Seed Yield/plant (g)							
	45 DAS		60 DAS		90 DAS		120 DAS	
	RCr 41	Acr 1	RCr 41	Acr 1	RCr 41	Acr 1	RCr 41	Acr 1
FWt	0.272	-0.095	0.569	-0.036	-0.042	-0.508	0.871	0.935
RWt	0.331	0.108	0.505	0.004	-0.320	-0.508	0.890	0.452
SWt	0.263	-0.193	0.568	-0.038	-0.027	-0.315	0.780	0.897
NuB	-	-	0.336	-0.038	-0.221	-0.565	0.688	-0.258
Rlen	-0.214	-0.296	0.591	0.574	-0.142	-0.589	-0.133	-0.519
Slen	0.595	-0.504	0.668	0.218	0.322	-0.409	-0.091	0.492
DWt	0.112	-0.117	0.522	-0.130	0.040	-0.781	0.811	0.949
FWt/DWt	0.250	0.067	-0.112	0.379	-0.280	0.585	-0.629	-0.753
SWt/RWt	-0.318	-0.213	0.202	-0.064	0.169	-0.314	-0.467	0.648
Slen/Rlen	0.567	-0.225	-0.126	-0.243	0.651	0.456	0.074	0.720

Table 5.33 Growth parameters and their correlation with seed yield in fennel

	Seed Yield/plant (g)							
	45 DAS		60 DAS		90 DAS		120 DAS	
	RF 101	AF 1	RF 101	AF 1	RF 101	AF 1	RF 101	AF 1
FWt	0.153	0.244	0.366	0.085	-0.284	-0.025	0.884	0.837
RWt	-0.190	0.250	0.464	0.051	-0.250	0.089	0.276	0.043
SWt	0.044	0.219	0.297	0.087	-0.280	0.087	0.895	0.816
NuB	-	-	-	-	-0.121	-0.317	0.295	0.260
Rlen	-0.219	0.503	0.174	0.124	-0.344	-0.002	0.050	0.386
Slen	0.033	0.696	0.080	0.108	-0.090	0.225	0.505	0.595
DWt	0.148	0.166	0.164	0.174	-0.006	0.188	0.881	0.846
FWt/DWt	0.069	0.054	0.160	-0.119	-0.153	-0.048	-0.472	-0.585
SWt/RWt	0.242	0.009	-0.288	0.057	-0.176	-0.066	0.015	0.172
Slen/Rlen	0.261	0.357	-0.006	-0.058	0.315	0.191	0.278	0.211

parameters showed positive correlation with yield in both the genotypes which is also reflected at 60 DAS. Fresh to dry weight ratio in both genotypes was negatively correlated with yield. Total chlorophyll content was more in RF 101at 75 DAS and in AF 1 at 100 DAS. Slight negative turgor was obtained in genotype AF 1 at post flowering stage.

Cumin (*Cuminum cyminum* L.)

In cumin fresh weight, shoot weight and dry weight is invariably more in genotype GC 4 and produced more seed yield. High ratio of shoot to root weight and shoot to root length showed direct relation with seed yield in cumin, however fresh to dry weight ratio showed no relation with yield. All studied crops showed slow growth up to 60-80 DAS and less variation in different physiological parameters but after that the variation was very much evident. Growth parameters at 60 and 90 DAS in genotype RZ 209 reflected same correlation at 120 DAS. Chlorophyll content was more at 100 DAS. Turgor

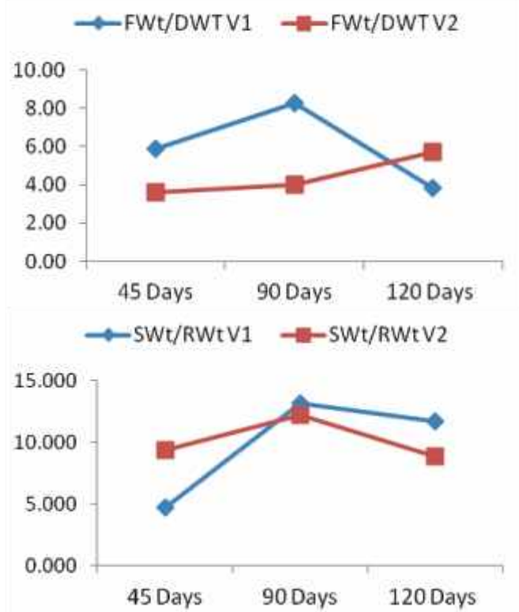


Fig. 25 Temporal variation in growth parameters of cumin

Table 5.34 Growth parameters and their correlation with seed yield in cumin

	Seed Yield/plant (g)							
	45 DAS		60 DAS		90 DAS		120 DAS	
	GC 4	RZ 209	GC 4	RZ 209	GC 4	RZ 209	GC 4	RZ 209
FWt	0.202	-0.329	0.047	0.089	-0.230	0.363	0.896	0.910
RWt	-0.229	-0.260	0.202	0.261	-0.110	0.326	0.732	-0.199
SWt	0.195	-0.351	0.053	0.093	-0.235	0.364	0.776	0.909
NuB			-0.159	0.471	0.354	0.256	0.461	0.763
Rlen	-0.343	-0.006	-0.322	0.008	0.479	0.737	0.821	0.623
Slen	-0.352	0.201	-0.370	0.155	-0.283	0.397	-0.122	0.284
DWt	0.249	-0.196	-0.145	0.053	-0.255	0.534	0.981	0.601
FWt/DWt	0.163	0.243	0.538	0.153	-0.111	-0.177	-0.411	0.713
SWt/RWt	0.163	-0.391	-0.309	-0.256	-0.289	0.089	0.345	0.257
Slen/Rlen	0.028	0.238	0.066	0.149	-0.467	-0.218	-0.712	-0.559

pressure was more in RZ 209 at pre flowering stage while at flowering stage GC 4 showed more turgor pressure.

5.4.2 Effect of some chemicals on low temperature tolerance in cumin and coriander

Sprays of selected chemical for induction of low temperature tolerance in cumin and coriander were assessed by measuring membrane stability. In both cumin and coriander a few treatments showed increased membrane stability under *in vitro* conditions. Interestingly, in coriander, seed yield was significantly increased in many treatments of selected chemicals. In cumin, however yield was increased but magnitude was not as in coriander. The same results were observed for two years.

ASA 3, 5, and 7 µM, Betain hydrochloride 1, 5 µM and Proline 200, 400 µM concentration were found superior over control in coriander ACr 1. In addition to ASA 1, 3, 7 µM, Betain 1 and 5 µM, ABA 1 and 7 µM and proline 200, 400 µM concentration were found superior over control in coriander RCr 41. Betain 1 µM concentration was found superior over control in cumin GC 4 while Proline 200 and 400 µM concentrations were found superior over control in cumin RZ 209

5.4.3 Effect of water stress on water relations, photosynthetic parameters and membrane integrity of coriander genotypes

Under midterm water stress the ratio of shoot length to root length and shoot weight to root weight were found important as the genotypes showing higher yield maintained less shoot length to root length ratio under stress conditions, however, ratio of shoot wt to root wt was more under stress condition. Similar situation is there during terminal water stress. Genotypes Sadhna, ND/Cor 60 Sudha, YS/Rc 66 and Swati showed higher yield under terminal water stress.

Total chlorophyll was more during terminal stress in most of the genotypes. Genotype Australia, LCC 91, LCC 101 were able to maintain more turgor pressure under midterm stress conditions while all the genotypes showed slightly negative turgor during terminal stress condition. Genotypes RCr 435, ACr1,

Table 5.35 Effect of chemicals on morpho-physiological parameters on coriander variety ACr 1

Acr 1	F Wt/D Wt		Shoot Len/Root Len		Shoot Wt/ Root Wt		Seed Wt (g/plant)
	Ist Spray	IInd Spray	Ist Spray	IInd Spray	Ist Spray	IInd Spray	
Proline (200 µM)	7.636	8.976	2.731	6.179	15.438	44.424	17.521
Proline (600 µM)	8.028	8.906	2.934	6.786	13.032	38.932	17.773
Betain (1 µM)	8.246	8.576	2.822	7.164	14.755	45.174	27.370
Betain (5 µM)	6.236	9.029	2.819	5.925	16.933	47.315	24.137
ASA (3 µM)	7.777	7.819	2.978	6.794	17.502	41.205	24.450
ASA (5 µM)	15.851	8.807	2.772	7.306	13.276	26.935	18.596
ASA (7 µM)	7.755	8.729	2.795	5.787	15.582	36.495	24.326
Control	7.318	8.340	2.781	5.592	15.662	28.107	13.160

Table 5.36 Effect of chemicals on morpho-physiological parameters on cumin variety RZ 209

RZ 209	F Wt/D Wt		Shoot Len/Root Len		Shoot Wt/ Root Wt		Seed Wt (g/plant)
	Ist Spray	IInd Spray	Ist Spray	IInd Spray	Ist Spray	IInd Spray	
Proline (200 uM)	3.898	4.198	2.654	2.257	14.167	13.909	2.185
Proline (400 uM)	5.101	5.072	2.774	2.641	16.143	15.088	2.193
Control	4.196	3.477	2.979	2.795	16.439	11.467	0.852

Swati, Sudha, ND/Cor 60, Sadhna and Australia were showing more essential oil % either in midterm or terminal water stress conditions. Enough variability is available in coriander. Genotypes showing good tolerance to water stress have been identified that can be used in breeding varieties for water limiting conditions. In the situation of limited water availability one can avoid midterm irrigation which will not adversely affected yield. Irrigation is essential at terminal growth stage

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

One field experiment was conducted to find out defense mechanism in cumin for wilt and blight diseases. Two genotypes of cumin (GC 4 and RZ 209) and four antioxidants 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 T_4 V_1 and T_6 V_2 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 controlled by antioxidant treatments. Plant defence related biochemical parameters such as total phenol and flavonoids were recorded in leaf and root. In leaf, it was observed maximum in T_6 of both genotypes while in roots it was maximum in T_8 of both the genotypes and minimum in control plants of both the genotypes. All the results were significant within treatments and their combinations with genotypes.

5.4.5 Quality profiling of coriander and fenugreek germplasm

Nine genotypes of coriander and 16 genotypes of fenugreek were taken for quality profiling. Volatile oil content in intact seeds of different genotypes of coriander was ranging from a minimum of 0. 10 % in RCr-436 to a maximum of 0.34% in Swati genotype and in ground seed powder, volatile oil was ranging from 0.080 % (RCr-436) to 0.310 % (sindhu). The oleoresin content of ground seeds was ranging from a minimum of 5.17% in Swati genotype to a maximum of 15.60% in Sindhu genotype.Total phenolic content (TPC) in conventionally ground seeds was ranging from a minimum of 19.46 (mg GAE/ crude extract) in Sudha genotype to a maximum of 62.39 (mg GAE/ crude extract) in genotype RCr-436. There is significant genotypic variation in total flavonoid content (TFC). In ground seeds it was ranging from a minimum 5.81mg/gm QE/crude extract in genotype ACr-1 to a maximum of 16.92 mg/gm QE/crude extract) in Swati genotype. Total antioxidant content in conventionally ground seeds was ranging from a minimum of 2.37 mg/gm BHTE/crude extract) in genotype Sindhu to a maximum of 6.47 mg/gm BHT E/ crude extract in genotype RCr-436.

In fenugreek genotypes, ground seeds oleoresin content was minimum in genotype RMT-351 (3.18%) and maximum in genotype AM-578 (7.86%).TPC in conventionally ground seeds was ranging from a minimum of 6.20 mg/g GAE/ crude extract in GM-2 genotype to a maximum of 20.42 mg/g GAE/crude extract in genotype Hisar Survna. TFC in conventionally grounded seeds was minimum 1.75 mg/gm QE/crude extract in genotype Pant ragini and maximum 2.89 mg/gm QE/crude extract in AM-329 genotype.Total antioxidant content in conventionally ground seeds was minimum (63.12 mg/gm BHT E/crude extract) in genotype AM-324 and maximum (95.80 mg/gm BHT E/crude extract) in genotype RMt 305. All the genotypes showed a positive relation in TPC/TFC with antioxidant content. Fatty acid methyl esters of oil from three genotypes of fenugreek showed large variation.

5.5 Social Science

Awareness and adoption of seed spices production technology

Three tehsils in each Ajmer, Jodhpur and Baran district and three villages in each tehsil (total 27 villages) were identified. One hundred farmers in each village were selected covering large, small and marginal group of farmers. The demonstrations were given to 18% of the selected farmers in each selected

Table 5.37 Demonstrations of cumin and coriander in different districts

S. No.	Name of district	Crop	Number of demonstrations	Area/ ha
1.	Ajmer	Cumin	162	27
2.	Jodhpur	Cumin	162	27
3.	Baran	Coriander	162	27
	Total		486	81

Table 5.38 Number of trainings on seed spices production technology in different districts

S. No.	Name of District	Number of training	Number of participants
1.	Ajmer	8	410
2.	Jodhpur	6	245
3.	Baran	9	427
	Total	23	1082

village every year. The total demonstration in 2011-12 were 486 covering 81 ha area (Table 5.37).The full package of practices was given as intervention comprising improved variety, seed treatment and chemical weed management.

Average yield of cumin (RZ 209) obtained in Ajmer and Jodhpur district was 8.43 q/ha and 6.14 q/ha as compared to local cumin variety which yielded 5.2 q/ha and 4.2 q/ha Ajmer and Jodhpur respectively. Increase in yield due to combined effect of seed, fungicide and weedicide in Ajmer and Jodhpur for Cumin crop was 62.11 % and 46.19 %, respectively over local variety and the B: C ratio of cumin in Ajmer and Jodhpur was 4.95 and 3.61 respectively.

Average yield of coriander (RCr-436) obtained in Baran district was 21.08% more (14.53 q/ha) as compared to average yield of local variety (12.00 q/ha). The B:C ratio for coriander crop in Baran district was 3.78 (Table 5.39).

Demonstration of Cumin in village Ratakot, Tehsil Masuda in Ajmer district

Demonstration of Coriander in village Doti, Tehsil Atru in Baran district

Development of seed spices atlas of India using GIS approach: Various seed spices growing states have been identified. For each state a base survey for crop acreage has been done on the basis of acquired data taking a reference year. Data was collected on area, production and productivity district wise for Rajasthan, Gujarat, Maharashtra, Bihar, Chhattisgarh and Andhra Pradesh for seed spices

Table 5.39 Performance of demonstrations on cumin and coriander in different districts

S. No.	Name of District	Crop	Variety	Demonstrated yield (q/ha)				Increase yield/ ha	B:C ratio
				Highest	Lowest	Average	Local-check		
1.	Ajmer	Cumin	RZ-209	12.60	5.40	8.43	5.20	62.11	4.95
2.	Jodhpur	Cumin	RZ-209	9.60	4.30	6.14	4.20	46.19	3.61
3.	Baran	Coriander	RCr-436	15.80	12.70	14.53	12.0	21.08	3.78

and other commodity. For Rajasthan and Gujarat state the GIS database had been prepared district wise for 2000-01 to 2009-10 year and thematic map had been generated for the seed spice atlas.

5.6 Externally funded Project:

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

Influence of micronutrients application on growth, yield and quality of fenugreek and coriander

The micronutrients application influenced the growth, yield attribute and yield of coriander significantly. Soil application of copper (11 kg/ha) with foliar application of iron (0.5 % W/v) resulted early germination i.e., in 10.22 and 10.11 days after sowing, respectively. Maximum yield was recorded 1651.54 kg/ha and 1633.62 kg/ha in the above said treatments, respectively. In fenugreek, early germination was recorded in copper (11 kg/ha) and iron (0.5 % W/v) treatments i.e. in 3.67 DAS and 3.33 DAS, respectively, Yield was also recorded maximum, 1740 kg/ha and 1694.31 kg/ha in the above said treatments, respectively.

Effect of different organic modules on growth, yield and quality of fenugreek and coriander

In order to test the organic modules for two varieties of fenugreek (AFg-1 and RMt-305) and coriander (ACr-1 and RCr-41), a randomised block design experiment (plot size 3 x 2 meters) was conducted with four replications. Three organic modules were tested as per Table 5.40.

The organic module M_1 gave maximum seed yield (1520 kg/ha) with high growth and yield parameters of coriander over M_2 and M_3 modules. Therefore, application of various organic sources of nutrition along with organic way of disease and insect pest management as prescribed in M_1 organic module are better for realizing higher growth, yield attributes and yield of coriander. ACr-1 variety of coriander performed better over RCr-41, which exhibited higher vegetative growth i.e. plant height at 30 days (4.23 cm), 60 days (11.07 cm), 90 days (91.19 cm) and at harvest (99.08 cm), and primary branches (8.08), as well as yield attributes viz. umbel/plant (16.92), umbellate/umbel (4.90) and seed/umbellate (10.21) and yield (1405.35 kg/ha). Thus, it is inferred that application of M_1 organic module along with improved variety ACr-1 is better for realizing high yield of coriander.

In fenugreek, M_1 module resulted significantly higher plant height at different stages (17.93 cm at 60 days, 51.83 cm at 90 days, 54.58 cm at harvest), branches/plant at harvest (11.00), number of pods/plant (43.17), number of seeds/pod (15.33), and yield/ha (1997.36 kg/ha) followed by M_3 organic module. Therefore, application of various organic sources of nutrition along with organic way of disease and insect pest management as prescribed in M_1 organic module are better for realizing higher growth, yield attributes and yield of fenugreek. RMt-305 variety of fenugreek performed better over AFg-1 for significantly higher vegetative growth, and yields.

Table 5.40 Details of different organic modules

Organic materials	Module 1	Module 2	Module 3
Vermicompost (5t/ha)	Yes	No	No
FYM (10 t/ha)	No	Yes	No
Sheep manure (10 t/ha)	Yes	No	Yes
Azotobacter (100ml/kg seed)+PSB (100 ml/kg seed)	Yes	Yes	Yes
ST (10g/kg seed) + SA of *Trichoderma* (2.5kg/ha)	Yes	Yes	Yes
Soil Application of Neem Cake (150kg/ha)	Yes	Yes	Yes
Foliar spray of Onion /Garlic extract (5%) 2kg/ha.	Yes	Yes	No
Foliar spray of Neem oil (2%) 5litre/ha	Yes	No	No
Foliar spray of Karanj Oil (2%) (5litres/ha)	No	No	Yes

5.6.2 Studies on cryogenic grinding for retention of flavour and medicinal properties of some important Indian spices (NAIP Component IV)

Effect of genotype and grinding technology was found significant on total sapogenin content (%) and diosgenin content (%) in fenugreek. Total sapogenin percentage was ranging from minimum of 9.35% in genotype RMT 1 to a maximum of 10.78 % in genotype RMT 305 in cryo ground seeds while in non cryo ground seeds showed sapogenin minimum 6.61% in RMT 1 to a maximum of 8.103% in AFg-1. Diosgenin percentage was significantly more in cryo ground samples of all three genotypes. In non cryo seeds it was ranging from 1.3 to 1.5% while increased significantly in cryo ground samples and ranged from 2.1 to 2.5%.

During storage of ground powder of fenugreek and coriander there was clear effect of cryogenic grinding on total phenolic, flavonoid content, oil content and antioxidant activity. These parameters were significantely more in cryo ground samples and the rate of decrease with time was also less as compare to non cryo ground samples.

Table 5.41 Effect of grinding technologies on recovery of total sapogenin and diosgenin in fenugreek genotypes.

Genotype	Total sapogenin (%)		Total diosgenin %	
	Cryo	Non-Cryo	Cryo	Non-Cryo
AM-1	10.023	8.103	2.113	1.393
RMT-305	10.780	7.683	2.317	1.327
RMT-1	9.350	6.610	2.557	1.577
	SEm±	**CD at 5%**	**SEm±**	**CD at 5%**
Grinding Technology (A)	0.075	0.226	0.025	0.075
Variety (B)	0.091	0.277	0.014	0.043
AxB	0.129	0.391	0.017	0.053
CV	2.968		2.672	

Table 5.42 Effect of storage time on total phenolic, flavonoid content, oil content and antioxidant activity of cryo and non cryo ground fenugreek seeds

Time after opening of packet	Total Phenolic Content (mg GAE/g Crude extract)		Total Flavonoid Content (mg QE/g Crude extract)		Total Antioxidant Content (mg BHT E/g Crude extract		Total oil content (%)	
Fenugreek genotype AM 1	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground
Initial	49.24	61.64	17.16	34.97	9.72	16.97	4.94	6.29
After 30 Days	36.02	48.51	11.73	26.20	6.25	12.62	3.60	5.63
After 45 Days	32.12	44.36	10.11	24.36	5.12	10.56	3.20	5.11

Table 5.43 Effect of storage time on total phenolic, flavonoid content, oil content and antioxidant activity of cryo and non cryo ground coriander seeds

Time after opening of packet	Total Phenolic Content (mg GAE/g Crude extract)		Total Flavonoid Content (mg QE/g Crude extract)		Total Antioxidant Content (mg BHT E/g Crude extract		Total oil content (%)		Essential oil content (%)	
Coriander genotype ACr 1	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground	Non cryo ground	Cryo ground
Initial	21.27	44.83	35.38	84.25	8.79	12.10	10	13.9	0.199	0.299
After 30 Days	13.02	32.72	23.71	50.029	5.56	9.33	9.045	11.89	0.159	0.239
After 45 Days	10.32	30.26	19.50	45.23	4.23	8.36	8.12	11.02	0.11	0.21

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

Large scale demonstrations of environment friendly biological control methods against insect pests and diseases of seed spices were conducted in Ajmer district. Total 19 villages of 5 development block were selected for cumin, coriander and fennel. Total of 140 farmers were given biocontrol agents *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. Training to the farmers was given for scientific use of these products at their respective villages. A two days training for 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 formulated biocontrol products were given to the farmers.

5.7 Seed Production

Mega seed project on seed production of agricultural crops and fisheries

During 2011-12 TFL seed production of improved varieties of cumin and fennel was taken at Farmer's field under Farmer's Participatory Seed Production Programme. A total of 105.61 quintal seeds of cumin varieties GC-4 and RZ-209 were produced.

Table 5.44 Breeder seed produced during 2011-12 at NRCSS, Ajmer

Crop	Variety	DAC Indent	Production (kg)
Coriander	Ajmer Coriander-1	Nil	16.2
Fennel	Ajmer Fennel-1	Nil	36.5
Fenugreek	Ajmer Fenugreek-1	Nil	462.2
Fenugreek	Ajmer Fenugreek-2	Nil	246.3
Ajwain	Ajmer Ajwain-1	Nil	32.5
Ajwain	Ajmer Ajwain-2	Nil	53.2
Dill	Ajmer Dill-1	Nil	29.8
Dill	Ajmer Dill-2	Nil	70.9
Nigella	Ajmer Nigella-1	Nil	17.1

6. Technology Assessed and Transfer

The centre is also involved in transfer of proven technologies by conducting training programmes and demonstration trials on new varieties and production technologies. Problems of seed spices growers and other stakeholders are attended at the centre by the experts of relevant fields and also provide literature on production technology of seed spices crops. Field visits, demonstration 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, Ajmer

6.1 Dissemination of seed spices production and technology under Natonal Horticulture Mission:

6.1.1 Farmers training at Aizawl, Mizoram

A training programme was organized during 13-14 December, 2012 on "Production, processing and value addition in Seed Spices" with a view to expand the seed spice growing area in non conventional but productive areas of North-Eastern states of India. Dr E. Cypari, Joint Director, Department of Horticulture, Govt of Mizoram inaugurated the training and emphasized on scope and possibilities of seed spices in Mizoram. 65 farmers participated in the training.

6.1.2 Farmers training at Sikar, Rajasthan

A two days training programme on Improvement in production, productivity and quality of seed spices" was organized by NRCSS, Ajmer at Sikar, Rajasthan. Dr. Balraj Singh, Director, NRCSS, Ajmer briefed about present scenario of seed spices in India. He pointed out the use of improved varieties and good agricultural practices in seed spices cultivation. During two days of this training, resource persons delivered lectures on global perspective, good agricultural practices for seed spices, improved varieties of seed spices, nutrient and water management in seed spices, role of compost and bio-fertilizers.

6.1.3 Farmers training at Pratapgarh, Rajasthan

A farmers training was organized at Pratapgarh, Rajasthan during 23 and 24 February 2013. Dr Balraj Singh, Director, NRCSS delivered the lecture on production and productivity of seed spices in the country and international scenario for export purpose. In this training programme, farmers

participated from the nearby 50 Km peripherial region of Pratapgarh. Most of the farmers were from the tribal belt of Pratapgarh region of the district, where agricultural technologies dissemination is quite low but is essential.

6.1.4 Training at CSWCRTI, Kota, Rajasthan

Kota and nearby area is very well known for coriander cultivation. To spread latest cultivation

practices of seed spices, a two days training programme was organized at CSWCRTI, Kota during 18-19 March 2013. Fifty progressive farmers attended the training.

6.1.5 Training under ATMA for Rajsamand farmers:

One four days (5-8, March 2013) and two five days (29 Oct-2 Nov and 3-7 Nov 2012) training

prorammes were organized on "Modern technologies for enhancing quality and productivity of seed spices" in collaboration with ATMA, Rajsamand. More than 100 farmers from Rajsamand district of Rajasthan participated in these training programmes and got benefitted.

6.1.6 Front line demonstration on fennel crop at Bhadal (Jaipur)

Two farmers Mr. Bheru Ram Yadav and Mr. Ram Lal Yadav had grown fennel in their fields (0.5 ha each). They harvested 7.5 to 8.0 q/ha yield of fennel amounting gross return ` 52500.00 to ` 56000.00. The returns were 46 to 55% higher over the average return of wheat crop per hectare.

6.1.7 Front line demonstration on Ajwain at Kudi road (Jaisalmer)

A farmer Mr. Mool Singh, at Kudi road (Jaisalmer) has grown ajwain crop (AA-1) in his land during the cropping season of 2011-12 and

harvested 630.00 kg/ha yield (Gross Return ` 75600.00). He used the production technology provided by NRCSS, Ajmer.

6.1.8 Field day

A field day on fennel crop was organized by NRCSS under NHM project on March 21, 2012 at Bhadal, Jaipur.

Scientists from NRCSS interacted with the farmers about recent fennel technologies with its economics and constraints for cultivation. They also advised the farmers to adopt fennel and other seed spices for the diversification from conventional cropping system and to have better economic returns.

6.1.9 Mass Campaign week (14-23 Feb, 2013)

A mass campaign week (14 -23, Feb, 2013) was organized in seed spices growing areas of Rajasthan for dissemination of technologies for improvement in quality of seed spices, their post harvest handling, processing and value addition.






Different group of stake holders *viz.* farmers, farm women, extension worker, students and traders were contacted through meetings, discussion, field days at various places like farmers field, chopal, temples, schools, Patwar Bhavan, KVK premises etc. During meetings seed spices expert delivered lecture on various aspect of improved production technology, post harvest management, quality improvement and value addition of seed spices. During meeting folders on improved production technologies of seed spices were also given to stake holders.

6.2 National Kisan Mela and *Kisan* Sanghosthi

The National Kisan Mela and Kisan Sanghosthi was organized on 15th February 2013 on the Mela ground of NRCSS. More than 1000 farmers, agriculture students, teachers, scientists and traders participated in this fair. The farmers fair was inaugurated by Shri Hawa Singh Hooda, Advocate General, Haryana Government, the Chief Guest of the function. Shri A.M. Tiwari, IAS and Managing Director, Gujarat Narmada Valley Fertilizers & Chemicals Ltd.(GNFC) and Dr. S. M. K. Naqvi, Director, Central Sheep and Wool Research Institute, Avikanagar were also present as Special Guest on this occasion. In *Kisan Gosthi* , experts, answered the questions raised by farmer on various problems faced by them in day to day agriculture operations for which easy solution were provided in local languages. Besides this, various teachers and researchers from state agricultural universities, KVKs as well as from officers from state government agencies involved in development, extension and marketing of spices and spice growers, exchanged their views and discussed with farmers on many aspects of crop production with special focus on seed spices. Innovative farmers were praised for their work and awarded with appreciation certificate. Stalls of




various agri-inputs and ICAR institutes were also awarded with appreciation certificate.

6.3 Seed Spices Knowledge Area

The Seed Spices Knowledge Area was developed in the project "Intellectual property management and transfer/commercialization of agriculture technology scheme" and Inaugurated by Sh. H.S. Hooda, Advocate General of Haryana on 15th February 2013. All the technologies developed at NRCSS are display through posters and live samples in the knowledge area.

6.4 Cryogenic Grinding Technology

The finding of the project titled "Studies on cryogenic grinding for retention of flavour and medicinal properties in some Indian spices" running

at NRCSS, Ajmer under NAIP showed that cryogenic ground coriander and fenugreek seeds were superior in terms of volatile oil content, total oil content and antioxidant properties. Apart from this, colour of ground powder is also superior to traditional ground powders. This value addition may fetch premium price of ground powders. People showed interest in bying cryoground coriander powder by paying higher prices.

6.5 Visit of farmers at centre's farm

A number of groups of farmers, students, researchers and traders have visited NRCSS research farm. During 2012-13 about 4000 famers, students from different areas, mainly form Rajasthan, Gujarat, Punjab, Haryana, U.P., UttaraKhand, M.P., Himachal Pradesh, Jharkhand and Maharashtra visited the centre under various training and visit programme. Numerous lectures were delivered by scientists to educate them by exhibiting the new technologies.

6.6 Radio talk

Name of Scientists	Topic	Date of Broadcast
Dr. Balraj Singh	Seed spice crops production in Rajasthan	25.11.2012

6.7 Television talks

Name of Scientists	Topic	Date of Broadcast
Dr. Balraj Singh	Importance of plastics in Horticulture (Hindi)	17.11.12 DD Jaipur
Dr. Gopal Lal	Importance and scope of seed spices cultivation in India	May 2012, DD New Delhi
Dr. Gopal Lal	Scientific cultivation of seed spices in Rajasthan	14.11.2012, DD Jaipur.
Dr. Gopal Lal	Post harvest handling and processing of seed spices	2.4.13, ETV Rajasthan
Dr. Ravindra Singh	jch e chth; elyk dh fdLe ,o mRiknu rduhd	22.09.12 DD Jaipur
Dr. Ravindra Singh	Fertigation and drip irrigation in seed spices	23.03.13 E TV Rajasthan

6.8 Exhibition conducted/Participated

Name and Date of event	Organizer and Venue	
Kisan Mela (12 September, 2012)	Central Arid Zone Research Institute (CAZRI), Jodhpur (Rajasthan).	
3rd International Agronomy Congress (26-30 November, 2012)	Indian Agricultural Research Institute, New Delhi	
National Seminar Production, Productivity & Quality of Spices (2-3 February, 2013)	National Research Centre on Seed Spices, Ajmer held at Panchayatiraj Bhavan, Jaipur	

Name and Date of event	Organizer and Venue	
National Farmers Fair and Kisan Gosthi (15 February, 2013)	National Research Centre on Seed Spices, Ajmer	
Kisan Mela (3 March, 2013)	Rajasthan State Government, Horticulture Department at Pushkar	
National Pusa Kisan Mela (6-8 March, 2013)	Indian Agricultural Research Institute, New Delhi	
Kisan Mela (23 March, 2013)	Central Sheep and Wool Research Institute, Avikanagar	

7.Education and Training

7.1 Education (Student guided)

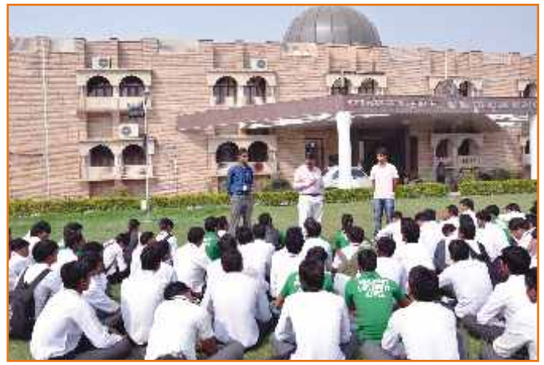
Student Name	Degree	Project title	Guide
Sumran Gujar	M.Sc.	Effect of different levels of sulphur and zinc on ACr-1 (*Coriandrum sativum* L.)	Dr. Gopal Lal
Naimuddin	M.Sc.	Effect of different organic sources of nutrients on growth yield and quality of fenugreek CV. RMt-305	Dr. Gopal Lal
Roshan Lal Meena	M.Sc.	Effect of weed management practices on growth, yield and quality of ajwain (*Trachyspermum ammi* L.) Lv. Ajmer Ajwain-1	Dr. S.S. Meena
Sarita Kumari	M.Sc.	Genetic variability and correlation studies in ajwain (*Trachyspermum ammi* L.) germplasm	Dr. S.S. Meena
Sohan Prakash Kumawat	M.Sc.	Genetic diversity analysis in ajwain (*Trachyspermum ammi* L.) germplasm	Dr. S.S. Meena
Manoj Kumar	M.Sc.	Effect of sowing dates and crop geometry on growth, yield and quality of dill (*Anethum gravelones* L.)	Dr. S.S. Meena
Kunj Bihari Agrawal	M.Sc.	Changes in physical and biochemical properties of fenugreek (*Trigonella Sp* L.) leaf during different growth stages	Dr. J. K. Ranjan
Rajesh Kumar	M.Sc.	Genetic Divergence and Correlation Studies in Fennel (*Foeneculum vulgarae* L.)	Dr. J. K. Ranjan
Rupesh Yogi	M.Sc.	Estimation of genetic variability in fennel (*Foeniculum vulgare* Mill.) germplsam for yield and its related traits	Dr. R. S. Meena
Mamta Jakhar	M.Sc.	DNA fingerprinting of *Trigonella foenum-graecum* (fenugreek) varieties using RAPD markers	Dr. Sharda Choudhary
Sharda Choudhary	M.Sc.	Genetic diversity analysis in *Trigonella foenum-graecum* (fenugreek) through molecular markers	Dr. Sharda Choudhary

7.1 Training Offered

S.N.	Title of the training	Date	No. of Scientists
1.	Modal Training Course on "Resource conservation techniques and micro - irrigation for precision input application in seed spices"	18 - 25 January, 2013	25

7.3 Agriculture Education

To create awareness among the students of the locality regarding agriculture research in general and seed spices in particular NRCSS always encourages the visit of local students. Students were allowed to see the experiments in fields and interact with the scientists of the institute. Seed spice knowledge area is specially developed by ITMU, NRCSS for demonstrating the technologies developed by NRCSS. During the reporting year almost 200 students from various schools and colleges visited the centre and got awared about seed spices research.



8. Awards and Recognition

8.1 Awards

Name of Personnel	Name of Award	Given by (Organizer/Place)
Dr. S. N Saxena (Principal Scientist)	Most industrious scientist of NRCSS for the year 2012 -13	Director, NRCSS on Republic Day 2013
Dr. Ravindra Singh (Senior Scientist)	Best scientist of NRCSS for the year 2012-13	Director, NRCSS on Republic Day 2013
Dr. R. S. Mehta (Senior Scientist)	J.S. Pruthi award for best research paper	Indian Society of Spices and Aromatic Plants, Calicut, Kerla
Sh. P. K. Agrawal (Technical Assistant)	Best technical person of NRCSS for the year 2012-13	Director NRCSS on Republic Day 2013
Sh. M. Vanvi (Assistant)	Best administrative staff of NRCSS for the year 2012-13	Director NRCSS on Republic Day 2013
Sh. Pukhraj Paroda (Supporting Staff)	Best supporting staff of NRCSS for the year 2012-13	Director NRCSS on Republic Day 2013

8.2 Recognitions

Name of Scientists	Particulars
Dr. Balraj Singh	Awarded Fellow of the Horticultural Society of India in 5th Indian Horticultural Congress held at PAU, Ludhiana on Nov 6 – 9, 2012.
	Elected as an Executive Councillor of the Horticultural Society of India for the period 2013-15
	Elected as Secretary of the Indian Society for Protected Cultivation (ISPC) in 2012
	Nominated as President of the Indian Society of Seed Spices, Ajmer
	Nominated as Advisor for establishment of a Centre of Excellence on Horticulture in Odisha state by the Department of Horticulture, Govt. of Odisha
	Nominated as Member of the committee for establishment of an Industrial Biotechnology Park in the state of Jammu and Kashmir by the Chairman, Scientific Advisory Committee of the Chief Minister of J & K, India
	Nominated as a Member of the Project Review Committee by the Department of Science and Technology, GOI, New Delhi
	Nominated as a Member of the Task force for finalizing DUS guidelines for coriander and fennel by PVP&FRA , New Delhi
	Acted as a Member of the “working group on protected cultivation in Haryana” constituted by the Haryana Farmers Commission
Dr. Gopal Lal	Member, Rajasthan Kisan Ayog, from November 2011
	Member, Seed Spices Task Force Committee, Cochin
	Member, Committee, Rajasthan State Agricultural Policy for XII Plan
	Secretary, Indian Society of Seed Spices, Ajmer from 2010 -11 to 12-13
	Reviewer for Indian Journal of Agricultural Sciences, Journal of Food Science and Technology, Indian Journal of Horticulture, Annals of Arid Zone, The Horticultural Journal, Haryana Journal of Horticultural Sciences and International Journal of Seed Spices.

Name of Scientists	Particulars
	Awarded for Best Poster Presentation in National Seminar on Production, Productivity & Quality of Spices, at Jaipur, February 2-3, 2013.
Dr. S. N. Saxena	Expert member in the Comprehensive Glossary of Agriculture Terms updation meeting of Commission for Scientific & technical terminology, Ministry of Human Resource Development, Govt. of India.
	Tresurer, Indian Society of Seed Spices, Ajmer
	Awarded for Best Poster Presentation in National Seminar on Production, Productivity & Quality of Spices, at Jaipur, February 2-3, 2013.
Dr. R. K. Kakani	Nominated as a member of the Task force for finalizing DUS guidelines for coriander and fennel by PVP&FRA, New Delhi
	Editor of International journal of Seed Spices
	Reviewer for Indian Journal of Agricultural Sciences, Journal of Spices and Aromatic Plants, International Journal of Seed Spices.
Dr. Y. K. Sharma	Awarded for Best Poster Presentation in National Seminar on Production, Productivity & Quality of Spices, at Jaipur, February 2-3, 2013.
	Reviewer for International Journal of seed spices published by Indian Society of Seed Spices, Tabiji, Ajmer.
Dr. R. S. Mehta	Reviewer for Indian Journal of Agricultural Sciences, Journal of Spices and Aromatic Plants, International Journal of Seed Spices.
Dr. Ravindra Singh	Fellow of Indian Society of seed spices, NRCSS, Ajmer
	Nominated as Councellor of Indian Journal of Agricultural Research, Karnal.
Dr. Krishnkant	Outstanding poster presentation in National Seminar on Production, Productivity & Quality of Spices, at Jaipur, February 2-3, 2013
	Editor of International Journal of Seed Spices
Dr. S. S. Meena	Chief editor of International Journal of Seed Spices
Dr. J. K. Ranjan	Fellow of Indian Society of Seed Spices, NRCSS, Ajmer
	Editor of International Journal of Seed Spices
Dr. S. S. Rathore	Fellow of Indian Society of Seed Spices, NRCSS, Ajmer
	Editor of International Journal of Seed Spices
Dr. B. K. Mishra	Acted as an expert member in the Comprehensive Glossary of Agriculture Terms updation meeting of Commission for Scientific & technical terminology, Ministry of Human Resource Development, Govt. of India
	Fellow of Indian Society of Seed Spices, NRCSS, Ajmer
	Editor of International Journal of Seed Spices
Dr. R. S. Meena	Nominated as a member of the Task force for finalizing DUS guidelines for coriander and fennel by PVP&FRA, New Delhi
Sh. Mukesh K. Vishal	Fellow Indian Society Seed Spices, NRCSS, Tabiji, Ajmer
	Outstanding poster presentation on "Spatial and temporal assessment of area, production and productivity scenarios of cumin in Rajasthan. In National Seminar on Production, Productivity and Quality of Spices held during 2-3 February 2013, at Jaipur, India.

9. Linkages and Collaborations

9.1 AICRP on Spices

Under the AICRP on Spices following trials were conducted at NRCSS during 2011-12

1. Coordinated Varietal Trial on Coriander
2. Coordinated Varietal Trial on Fennel
3. Coordinated Varietal Trial on Fenugreek
4. Coordinated Varietal Trial on Cumin
5. PGPR Trial on Cumin, Coriander and Fennel
6. Coordinated Trial on leafy type coriander for summer season

9.2 AICRP on Vegetables

Intercropping of Cabbage, Carrot and Pea with Seed Spices

9.3 Various ICAR Institutes/ SAUs/State Agriculture/Horticulture departments

The National Research Centre on Seed Spices is maintaining linkages with the following institutes/agencies

- Indian Institute of Spices Research (IISR), Calicut
- National Bureau of Plant Genetic Resources (NBPGR), New Delhi
- All India Coordinated Research Project on Spices, (AICRPS) Calicut
- Central Arid Zone Research Institute (CAZRI), Jodhpur
- Central Institute of Arid Horticulture (CIAH), Bikaner
- SAU's such as SKRAU, Bikaner, MPUAT, Udaipur, SDAU, Dantiwada, CCS, HAU, Hisar, SKUAT, Sri Nagar, APHU, Hyderabad and NDUAT, Faizabad.
- Spices Board, Cochin
- Directorate of Arecanut and Spices development (DASD), Calicut
- Protection of Plant Varieties and Farmer Rights Authority (PPVFRA), Govt of India, New Delhi
- Central Institute of Post Harvest Engineering and Technolog (CIPHET), Ludhiana
- Farmers, NGOs and KVKs

10. Publications

10.1 Research Papers in National/ International Journals

10.1.1 International

1. Liu Y, Kakani RK and Nair MG (2012) Compounds in functional food fenugreek spice exhibit anti-inflammatory and anti-oxidant activities. *Food Chemistry* 131:1187-1192
2. Singh SK, Kakani RK, Meena RS, Pancholy A, Pathak R and Raturi A (2012) Studies on genetic divergence among Indian varieties of a spice herb *Coriandrum sativum. Journal of Environmental Biology* 33: 781-789
3. Singh SK, Kakani RK, Meena RS, Pancholy A and Pathak R (2012) Genetic diversity among Indian varieties of *Foeniculum vulgare* and *Cuminum cyminum* based on nuclear ribosomal DNA and RAPD analyses. *International Journal of Agricultural and Statitistical Sciences* 8(2): 493-502

10.1.2 National

1. Agrawal KB, Ranjan JK, Rathore SS, Saxena SN and Mishra BK (2013) Change in physical and biochemical properties of fenugreek (*Trigonella Sp*.) leaf during different growth stages. *International Journal of Seed Spices* 3(1): 31-35
2. Aishwath OP, Lal G, Kant K, Sharma YK, Ali SF and Naimuddin (2012) Influence of biofertilizers on growth and yield of coriander (*Coriandrum sativum* L.) under typic haplustepts. *International Journal of Seed Spices* 2(2): 9-14
3. Godara AS, Gupta US, Singh R and Mehta RS (2012) Effect of different combinations of organic and inorganic nutrient sources on productivity and profitability of fenugreek (*Trigonella foenum-graecum*). *International Journal of Seed Spices* 2(2):34-37
4. Kant K, Mehta RS, SharmaYK, Meena SR and Meena RD (2013) Colonization pattern of aphid (*Hydaphis coriandri* Das) and predator coccinella (*Coccinella septempunctata* L.) on fennel crop. *International Journal of Seed Spices* 3(1): 44-47
5. Kant K**,** Ramanujam B, Tyagi SK, SharmaYK, Meena SS, Mishra BK, Vishal MK and Meena SR (2013) Management of fennel aphids (*Hydaphis coriandri* Das) through biorational approaches. *Annals of Plant Protection Sciences* 21(1): 21-23
6. Meena ML, Singh D and Meena SS (2013) Effect of front line demonstrations on yield enhancement of fenugreek: A case study in arid zone of Rajasthan. *International Journal of Seed Spice* 3(1)64-67
7. Meena RL, Meena SS and Mehta RS (2012) Effect of weed management practices on growth of ajwain (*Trachyspermum ammi* L.). *International Journal of Seed Spice* 2(2):15-18
8. Meena SS, Mehta RS, Lal G and Anwer MM (2012) Effect of agronomic practices on productivity and profitability of anise (*Pimpinella anisum* L.). *Journal of Spices and Aromatic Crops* 21(2: 102-105
9. Meena SS, Mehta RS, Lal G, Kant K, Sharma YK, Saxena SN and Anwer MM (2012) Essential oil, fatty oil and seed yield of nigella (*Nigella sativa* L.) as influenced by sowing dates and crop geometry. *Indian Journal of Horticulture* 69(4): 591-593
10. Meena SS**,** Singh B, Singh D, Ranjan JK and Meena RD (2013) Pre and post harvest factors effecting yield and quality of seed spices. *International Journal of Seed Spice* 3(1):1-11
11. Mehta RS, Anwer MM and Malhotra SK (2012) Influence of sheep manure, vermi-compost and bio-fertilizer on growth, yield and profitability of cumin (*Cuminum cyminum* L.) production. *Journal of Spices and Aromatic Crops* 21(1): 16-19
12. Mehta RS, Anwer MM and Sharma YK (2012) Effect of irrigation, nutrient levels and crop geometry on growth and yield of dill (*Anethum sowa* L.). *Journal of Spices and Aromatic Crops* 21 (1): 20-24
13. Mehta RS**,** Meena SS and Vishal MK (2013) Yield and economic feasibility of ajwain (*Trichispermi ammi* L.) production under varying irrigation interval, nutrient levels and crops geometry. *Agricultural Science Digest* 33(1):56-59
14. Mehta RS, Patel BS and Bhagirathram (2013) Yield and nutrient uptake of fenugreek (*Trigonella foenum-graecum* L.) as influenced by nitrogen, phosphorus and bio-fertilizers. Annals of Agricultural Research New Series 33(1&2):45-52
15. Naruka IS, Singh PP, Barde M and Rathore SS (2012) Effect of spacing and nitrogen levels on growth, yield and quality of Ajwain (*Trachyspermum ammi* [L.] Sprague). *International Journal of Seed Spices* 2(1): 12-17
16. Rana S, Singh PP, Naruka IS and Rathore SS (2012) Effect of nitrogen and phosphorus on growth, yield and quality of black cumin (*Nigella sativa* L.). *International Journal of Seed Spices* 1(2): 5-8
17. Rathore SS, Saxena SN, Saxena R and Tilak R (2013) Analysis of medicinally important compounds and antioxidant activity in fixed and essential oil of Dill (*Anethum graveolens* L.) genotypes. *International Journal of Seed Spices* 2(1): 12-15
18. Saxena R, Rathore SS, Bernwal P, Soni A, Sharma L and Saxena SN (2013) Effect of cryogenic grinding on recovery of diosgenin content in fenugreek (*Trigonella foenum-graecum* L.). genotypes. *International Journal of Seed Spices* 2(1): 26-30
19. Saxena R, Saxena SN, Barnwal P, Rathore SS, Sharma YK and Soni A (2012) Estimation of antioxidant activity, phenolic and flavonoid content of cryo and conventionally ground seeds of coriander (*Coriandrum sativum* L.) and fenugreek (*Trigonella foenum-graecum* L.). *International Journal of Seed Spices* 2(1): 89-92
20. Saxena SN, Agarwal D, Saxena R and Rathore SS (2012) Analysis of anti-oxidant properties of ajwain (*Trachyspermum ammi* L) seed extract. *International Journal of Seed Spices* 2(1): 50-55
21. Saxena SN, Khan IU and Saxena R (2012) Organogenesis in anise (*Pimpinella anisum* L.). *Journal of Spices and Aromatic Crops* 21(1): 59-63
22. Saxena SN, Kothari P, Rathore SS, Khan IU and Saxena R (2012) Organogenesis in fennel (*Foeniculum vulgare* Mill.). *International Journal of Seed Spices* 2(2):1-4
23. Sharma YK, Chowdappa P and Anwer MM (2013) Efficacy of fungicides for the management of *Alternaria* blight of cumin. *International Journal Seed Spices* 3 (1): 48-49
24. Singh DK, Choudhary PC and Khan MA (2012) Response of direction of sowing on coriander (*Coriandrum sativum* L.) varieties in Baran district of Rajasthan. *International Journal on Seed Spices* 2(2): 54-56
25. Vishal MK, Aishwath OP, Singh R, Mehta RS, Mishra BK, Obi Reddy GP and Kumar N (2013). Spatial and temporal assessment of area, production and productivity of cumin in Rajasthan. *International Journal of Seed Spices* 3(1): 70-76
26. Yadav A, Patel JC, Mehta RS and Meena T (2012) Growth, yields and economics of cumin (*Cuminum cyminum* L.) production as affected by weed management practices. *International Journal of Seed Spices* 2(2):27-33

27. Yogi R, Meena RS, Kakani RK, Panwar A and Solanki RK (2013) Variability of some morphological characters in fennel (*Foeniculum vulgare* Mill.). *International Journal Seed Spices* 3(1):41-43

10.2 Books

1. Choudhary S, Khan MA, Singh R, Aishwath OP and Singh B (2013) Recipe book (bilingual) "Spices Fragrance" "Masala Sugandh". *Published by Director, NRCSS, Ajmer.* pp: 117
2. Choudhary S, Solanki RK, Singh B, Lal G, Singh R, Meena RS, Meena SS, Mishra BK and Maheria SP (2013) *Naveentam Beejiya Masala Utpadan Taknik*. *Published by Director, NRCSS, Ajmer.* pp: 116
3. Lal G**,** Anwer MM, Mehta RS, Meena SS and Maheria SP (2012) Major seed spices Production technology. *Published by Agrotech Publishing Academy, Udaipur.* pp: 248
4. Lal G, Saxena SN, Mehta RS, Rathore SS, Godara AS and Vishal MK (2013) Book of Abstracts for National seminar on production, productivity and quality of spices. *Published by Director, NRCSS and Director, DASD, Calicut.* pp: 232
5. Lal G, Saxena SN, Mehta RS, Rathore SS, Godara AS and Vishal MK (2013). Souvenir of National seminar on production, productivity and quality of spices. *Published by Director, NRCSS, Ajmer and Director, DASD, Calicut.* pp: 244
6. Rathore SS, Lal G, Kant K, Saxena SN, Chaturvedi J and Singh B (2013) Good packaging practices for spices. *Published by NRCSS, Ajmer and KVS, Ajmer.* pp:108
7. Singh R, Lal G, Mehta RS, Choudhary S and Singh B (2013) Resource conservation technologies for seed spices*. Published by Director, NRCSS, Ajmer.* pp: 308

10.3 Technical Bulletins & Training Manuals

1. Aishwath OP, Singh B, Kant K, Sharma YK, Rathore SS, Solanki RK and Khan MA (2012) *Vilayati sauf ke unnat kheti. Published by Director, NRCSS, Ajmer*. pp: 24
2. Aishwath OP, Anwer MM, Mehta RS, Lal G, Singh R, Mishra BK and Meena SS (2012) Advances in nutrient management in seed spice crops. *Published by Director, NRCSS, Ajmer*. pp: 28
3. Aishwath, OP Anwer, MM, Mehta, RS, Meena, RL and Jha, BK (2012) Niche Plasticity of Spices, Medicinal and Aromatic Plants with Abiotic Stresses. *Published by Director, NRCSS, Ajmer.* pp:42
4. Aishwath, OP, Anwer, MM, Kant, K, Sharma, YK, Meena, RS (2012) Vulnerability and adaptability of seed spices with climate change. *Published by Director, NRCSS, Ajmer*. pp:28
5. Kant K, Sharma YK, Lal G, Singh B, Ranjan JK, Mishra BK, Meena RD and Meena SR (2013) *Beejiya masalon me samanwit keet evam rog prabandhan. Published by Director, NRCSS, Ajmer.* pp: 44
6. Lal G, Singh R, Saxena SN, Aishwath OP, Kakani RK, Sharma YK, Kant K, Mishra BK, Rathore SS, Meena SS, Meena RS, Solanki RK and Choudhary S (2012) *Krishak Prashikshan Manual: Bijiya masala faslotpadan avem Sasyotar Prodoyogiki. Published by Director, NRCSS, Ajmer.* pp: 104
7. Meena SS, Kakani RK, Singh B and Meena RD (2013) *Bijiya masala utpadan taknik-Krishak prashikshan manual*. *Published by Director, NRCSS, Ajmer.* pp: 120
8. Meena SS, Mehta RS, Ranjan JK, Rathore SS, Mishra BK, Solanki RK and Meena RD (2013) *Beejiya Masaala Surabhi. Published by Director NRCSS Ajmer.* pp: 114
9. Singh R, Misra, BK, Ranjan, JK, Choudhary, S and Singh, B (2013). *Krishak Parshikashan Manual "Beejiya Masalon ki Utpadakta evamn Gunwatata vradhi hettu aadhunik Taknikiyan". Published by Director, NRCSS, Ajmer*. pp:123.
10. Singh R, Lal G, Meena RS, Choudhary S and Maheria SP (2012) Improved seed spices and agricultural production technologies (in Hindi)., *Published by Director NRCSS, Ajmer.* pp: 104

10.4 Book Chapters

1. Aishwath OP (2012) Integrated nutrient management in seed spice based cropping system. *In: System based integrated nutrient management (Eds. Gangwar B and Singh VK). Published by New India Publishing Agency, Pitampura, New Delhi.* pp 327-338
2. Aishwath OP (2013) Improving resource use efficiency in saline alkali environment with seed spices. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer*. pp 160-170
3. Aishwath OP (2013) Micronutrients: Deficiency symptoms and management. *In: Recent production technologies of seed spices (Hindi). Published by Director, NRCSS, Ajmer*. pp: 33-35
4. Choudhary S, Singh R, Meena RS and Panwar A (2013) Biotechnological tools (molecular markers) to develop resource efficient varieties. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer*. pp 235-243
5. Choudhary S, Singh R, Meena RS, Godara AS and Panwar A (2013) *Beejiya masalo ko unnat banana hetu jaiv prodhyigiki ka upyog. In: Naveentam Beejiya Masala Utpadan Taknik. Published by Director, NRCSS, Ajmer*. pp:16-19
6. Gupta R, Anwer MM and Sharma YK (2012) Dill. *In Handbook of herbs and spices, Volume 1, Second edition (Ed: Peter KV). Woodhead Publishing Limited, 80 High Street, Sawston, Cambridge , UK.* pp: 275-285
7. Kakani RK and Anwer MM (2012) Fenugreek. *In Handbook of herbs and spices, Volume 1, Second edition (Ed: Peter KV). Woodhead Publishing Limited, 80 High Street, Sawston, Cambridge , UK*. pp 286-298
8. Kant K, Meena SR, Kumar M, Ranjan JK and Mishra BK (2013) Important insect pests of seed spices crops and their management. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer. pp.* 256-262
9. Kant K, Singh B and Meena SR (2013) Environment friendly green technology for management of coriander aphids (*Hyadaphis coriandri* Das) and its impact on predator population. *In Global scenario in environment and energy (Eds: Suresh S and Sudhakar K) BS Publications, Hyderabad.* pp: 317-321
10. Lal G and Mehta RS (2013) Post harvest handling, processing and value addition of seed spices. *In: Souvenir of National seminar on Production, productivity and quality of spices. Published by Director, NRCSS, Ajmer.* pp 184-192
11. Lal G, Singh B, Mehta RS, Meena SS, Singh R, Godara AS and Maheria SP (2013) Protected cultivation of seed spices: Prospectus, possibilities and benefits. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer.* pp 60-67
12. Lal G, Singh R and Cheepa BG (2013) Major Seed Spices: Production by scientific methods. *In: Recent seed spices production techniques (Hindi). Published by Director, NRCSS, Ajmer.* pp 20-23
13. Maheria SP, Lal G, and Singh R (2013) *Beejiya Masaalon mein Yantrikaran. In: Naveentam Beejiya Masaala Utpadan Takneek*. *Published by Director NRCSS Ajmer.* pp:45-47
14. Maheria SP, Lal G, Mehta RS, and Singh R (2013) Mulching practices to improve water use efficiency in field crops. *In: Resource*

conservation technologies for seed spices. Published by Director, NRCSS, Ajmer. pp 300-306

15. Meena RD, Sharma YK, Kant K, Meena SS, Meena RS, Vishal MK and Meena RL (2013) Soil solarization cum mulching for better soil health. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer.* pp. 276-279
16. Meena SS, Mehta RS, Meena RD and Ranjan JK (2013) Integrated nutrient management in seed spices. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer.* pp. 171-187
17. Mehta RS, Lal G and Meena SS (2012) Organic Farming: A Way for Sustaining Productivity of Seed Spices. *Potential Prospective of Underutilized Plant Species (Eds Behera KK). Published by Nerandra Publishing House, Delhi*, pp. 61-73
18. Mehta RS, Meena SS and Singh R (2013) Fertigation through drip and micro sprinkler system in seed spices. *Resource Conservation Technologies for Seed Spices. Published by Director NRCSS, Ajmer.* pp.133-136
19. Mishra BK, Ranjan JK, Sharma A and Kant K (2013) Soil microbial health under resource conserving techniques. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer.* pp 263-275
20. Rathore SS, Saxena SN and Singh B (2013) Export and quality aspects of seed spices. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer.* pp: 227-234
21. Saxena SN and Rathore SS (2013) Exogenous application of plant growth regulator for improving yield and abiotic stress tolerance in seed spices. *In: Resource conservation technologies for seed spices. Published by Director, NRCSS, Ajmer.* pp: 216-226
22. Sharma YK, Kant K and Meena RD (2013) Integrated disease management in seed spices. *In : Resource Conservation Technologies for Seed Spices. Published by Director, NRCSS, Ajmer.* pp 244-255
23. Vishal M K, Singh, Mehta RS, Aishwath OP and Kumar N (2013). Application of GIS and remote sensing for efficient use of resources for Precision Agriculture. *In: Resource Conservation Technologies for Seed Spices. Published by Director, NRCSS, Ajmer.* PP: 280-287

10.5 Popular articles

1. Aishwath OP (2012) Micronutrient management in seed spices. *In: Production of seed spices and postharvest technology (Hindi). Published by Director, NRCSS, Ajmer*. pp 33-35
2. Aishwath OP, Mehta RS, Singh R, Mishra BK, Lal G, Meena SS and Ranjan JK (2012) Micronutrient management in seed spices and other crops. *In: "Bijiya Masala Surabhi" Published by Director, NRCSS, Ajmer*, pp 50-52
3. Choudhary S, Singh R, Meena RS, Saini M, Choudhary V and Panwar A (2012) *Jaiv prodhyogiki evam beejiya masale: Ek nayee shuruaat*. *In: Masala utpadak krashak prashikshan manual: Unnat beejiya masala evam krishi utpadan prodhyogikiya. Published by Director, NRCSS, Ajmer.* pp:16-19
4. Choudhary S, Singh R, Panwar A and Meena RS (2013) *Aadhunik jaiv prodhyogiki ka beejiya masala fsalo me sudhar hetu sambhawanaye*. *In: Beejiya Masala Surabhi*. *Published by Director, NRCSS, Ajmer.* pp: 88-90
5. Kant K, Meena RD and Meena SR (2012) *Bijiya masala faslo me samekit keet prabhandhan*. *In: Krishak Prasikshan Manual: Bijiya masala faslotpadan evam Sasyotar Prodoyogiki. Published by Director, NRCSS, Ajmer.* pp: 48-51

6. Kant K, Meena SR, Ranjan JK and Mishra BK (2013) *Beejiya masala faslon me samekit nasijeev prabhandhan*. In *Beejiya Masala Surabhi. Published by Director, NRCSS, Ajmer* pp: 22-27
7. Kant K, Mehta RS, Meena SR and Agrawal PK (2012) *Sauf Ki podhasala evam ropad ki takniki (In Hindi). Fal Ful* 33(3): 28-29
8. Lal G (2012) Advance production technology of coriander (Hindi). *In: Farmers training manual: Advance production technology of seed spices crops (Hindi) (Eds. Mehta RS, Khan MA, Meena RS and Lal G) Published by Director, NRCSS, Ajmer*. pp: 3-5
9. Lal G and Sharma Y K (2013) Post-harvest processing and value addition of seed spice crops (Hindi). *In: Bijiya Masala Shurbhi. Published by Director, NRCSS, Ajmer*, pp: 46-49
10. Lal G, Singh R and Cheepa BG (2012) Cultivation of major seed spices (Hindi). *In: Training manual of seed spices growers (Hindi). Published by Director, NRCSS, Ajmer.* pp: 20-23
11. Maheria SP, Lal G, Mehta RS and Singh R 2013. *Beejiya masalon mein yatrikaran ka mahatav. In: Beejiya Masaala Surabhi. Published by Director, NRCSS Ajmer*. pp 86-87
12. eh.kk vkj Mh] eh.kk vkj ,l] lkydh vkj d] pk/kjh ,l] dkUr d ,o eh.kk ,l vkj ½2013½ e[; chth; elyk Qlyk dk vkfFkd egRo] budh fcekfj;k rFkk mudk mfpr ic/kuA**chth; elyk dh mRikndrk ,o x.koRrk of) gr vk/kfud rduhfd;k&d"kd if'k{k euvy**A i t u- 74&80-
13. eh.kk vkj Mh] 'kek okb d] flg ch] yky th] eh.kk vkj ,l ,o eh.kk ,l vkj ½2013½- chth; elyk e enk tfur jkxk] ,o dhVk d ic/ku gr enk lkyjkbt 'kuA**chth; elyk dh mRikndrk ,o x.koRrk of) gr vk/kfud rduhfd;k&d"kd if'k{k euvy**A i t u- 56&58-
14. eh.kk vkj Mh] 'kek ok; d] eh.kk ,l ,l] eh.kk vkj ,l] dkUr d] feJ ch d ,o eh.kk vkj ,y ½2013½ e[; chth; elyk Qlyk dh 0;kf/k;k rFkk icU/kuA **chth; elyk ljfHk**A i t- u- 14&21
15. Mishra BK and Sharma A (2012) *Beejiya masala fasalo me jaiv urvarko ka upyog avam prabhav. In: Krishak Prashiskshan Manual, Unnat Bijiya masal avam krishi utpadan proudhogikiya*. *Published by Director, NRCSS, Ajmer*. pp: 39-41
16. Mishra BK, Ranjan JK and Sharma A (2013) Jaiv urvarko ka beejiya masalo me upyog. *In: Naveentum Bijiya masal utpadan Taknik. Published by Director, NRCSS, Ajmer.* pp: 39-41
17. Mishra BK, Sharma A, Ranjan JK and Chauhan N (2013) *Compost banane ki unnat vidhiyan*. In *Beejiya Masala Surabhi. Published by Director, NRCSS, Ajmer.* pp: 97-98
18. Ranjan JK, Mishra BK, Pragya and Kant K (2013) Methi ka beejotpadan. *In: Samekit fasal prabhandhan mein unnat beej ka mahatva. Souvenier ICN:H/128/2013 (Eds Kumar A, Solanki IS, Kumar A, Raj R and Rao BUM). Published by IARI-Regional Station, Pusa.* pp: 66-68
19. Singh, B and Hassan, M (2012) *Jharkhand ke aadiwasi krishiko ke khet per kum daam sinchai pranali ki safalta ki kahani*. *Khad Pratika* 53(3):39-41
20. flg vkj] pk/kjh ,l ,o flg ch 2013- chth; elyk Qlyk d fy, ty ic/ku ,o vk/kfud flpkb i.kkfy;k ½chth; elyk ljfHk½ idkf'kr }kjk Mk-cyjkt flg] fun'kd] jk"Vh; chth; elyk dUn] vtej i"B l[;k 33&36
21. flg vkj] yky th] xknkj ,l] pk/kjh ,l ,o egfj;k ,l ih 2013- flpkb ,o ty ic/ku }kjk chth; elyk Qlyk e mRiknu of) ¼uohure chth; elyk mRiknu rduhd½ idkf'kr }kjk Mk-

cyjkt flg] fun'kd] jk"Vh; chth; elkyk dUn] vtej i"B l[;k 30&32

22. flg vkj] yky th] xknkjk , ,l] pk/kjh ,l ,o egfj;k ,l ih ¼2013½- flpkb ,o ty ic/ku }kjk chth; elkyk Qlyk e mRiknu of) ¼uohure chth; elkyk mRiknu rduhd½ idkf'kr }kjk Mk- cyjkt flg] fun'kd] jk"Vh; chth; elkyk dUn] vtej i"B l[;k 30&32

23. egrk vkj ,l] yky th] ,'oFk vk ih] eh.kk ,l ,l] [kku ,e , ,o vxoky ih ¼2012½ lefUor ik"kd rRo icU/kr% chth; elkyk Qlyk eA elkyk mRiknd d"kd if'k{k.k euvy**mUur chth; elkyk ,o df"k mRiknu ik/kkfxfd;k**A i t u- 71&73

24. egrk vkj ,l] flg ch] eh.kk ,l ,l ,o flg vkj ¼2012½ chth; elkyk Qly% tfod [krh **uohure chth; elkyk mRiknu rduhd**A i t u-81&85

25. egrk vkj ,l] yky th] eh.kk ,l ,l] flg vkj] ,'oFk vk ih] feJ ch d ,o jtu t d ¼2013½ tfod fof/k l chth; elkyk Qlyk dk mRiknuA **chth; elkyk ljfHk**A i t u- 41&45

26. egrk vkj ,l] yky th] ,'oFk vk ih] eh.kk ,l ,l] flg vkj ,o xknkjk , ,l ¼2013½ chth; elkyk Qlyk dk vf/kd mRiknu% lEcfU/kr ik"kd rRo icU/ku }kjkA**chth; elkyk dh mRikndrk ,o x.koRrk of) gr vk/kfud rduhfd;k&d"kd if'k{k.k euvy**A i t u- 71&73

27. egrk vkj ,l] flg ch] eh.kk ,l ,l ,o flg vkj ¼2013½ chth; elkyk Qly% tfod [krhA**chth; elkyk dh mRikndrk ,o x.koRrk of) gr vk/kfud rduhfd;k&d"kd if'k{k.k euvy**A i t u- 81&85

10.6 Extension folders

1. eh.kk ,l ,l] eh.kk vkj ,l] jtu t d] jkBkM ,l ,l] feJ ch d] lkydh vkj d ,o eh.kk vkj Mh ¼2013½- **thjk mRiknu dh mUur ik|kfxdh** ilkj i=d&1 idk'kd% fun'kd] jk"Vh; chth; elkyk vul/kku dUn] rchth] vtejA

2. eh.kk ,l ,l] eh.kk vkj ,l] jtu t d] jkBkM ,l ,l] feJ ch d] lkydh vkj d ,o eh.kk vkj Mh ¼2013½- **/kfu;k mRiknu dh mUur ik|kfxdh** ilkj i=d&2 idk'kd% fun'kd] jk"Vh; chth; elkyk vul/kku dUn] rchth] vtejA

3. eh.kk ,l ,l] eh.kk vkj ,l] jtu t d] jkBkM ,l ,l] feJ ch d] lkydh vkj d ,o eh.kk vkj Mh ¼2013½- **eFkh mRiknu dh mUur ik|kfxdh** ilkj i=d&3 idk'kd% fun'kd] jk"Vh; chth; elkyk vul/kku dUn] rchth] vtejA

4. eh.kk ,l ,l] eh.kk vkj ,l] jtu t d] jkBkM ,l ,l] feJ ch d] lkydh vkj d ,o eh.kk vkj Mh ¼2013½- **lkQ mRiknu dh mUur ik|kfxdh** ilkj i=d&4 idk'kd% fun'kd] jk"Vh; chth; elkyk vul/kku dUn] rchth] vtejA

5. eh.kk ,l ,l] eh.kk vkj ,l] jtu t d] jkBkM ,l ,l] feJ ch d] lkydh vkj d ,o eh.kk vkj Mh ¼2013½- **vtok;u mRiknu dh mUur ik|kfxdh** ilkj i=d&5 idk'kd% fun'kd] jk"Vh; chth; elkyk vul/kku dUn] rchth] vtejA

6. flg vkj] yky th] pk/kjh ,l ,o flg ch ¼2013½- chth; elkyk Qlyk e cn&cn flpkb i.kkyh }kjk lVhd ,o mojd ic/ku idkf'kr }kjk Mk- cyjkt flg] fun'kd] jk"Vh; chth; elkyk dUn] vtej

7. egrk vkj ,l] yky th] eh.kk ,l ,l] jfoUn ,l] jtu t d] ,'oFk vk ih ,o feJk ch d ¼2013½ **tfod fof/k l chth; elkyk Qlyk dk mRiknu** ilkj i=d&11 idk'kd% fun'kd] jk"Vh; chth; elkyk vul/kku dUn] rchth] vtejA

10.7 Research papers/ Abstracts presentation in conferences/ Symposia/ Seminar/ workshop/ other forum

1. Aishwath OP (2012) Response of seed spices and medicinal plants to zinc nutrition. *In: Proc. Global Conference on Horticulture for Food,*

Nutrition and Livelihood Options held at Bhubaneswar, Odisha, India from May 28-31, 2012.

2. Aishwath OP, Lal G, Naimuddin, Singh B, Kant K and Sharma YK (2012) Quality assessment of manures and their impact on *Trigonella foenum-graceum* and soil available nutrients under Typic Haplustepts. *77th Annual Convention of Indian Society of Soil Science held at Ludhiana, Punjab from Dec 3-6, 2012.*

3. Aishwath OP, Malhotra SK, Singh R and Panwar A (2013) Nutrient uptake distribution in some important cultivars of cumin for nutritional budgeting. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, ISSS, Ajmer at Jaipur from Feb 2-3, 2013.*

4. Bairwa HL, Meena KK, Mahawer LN and Meena SS (2013) Performance of ajwain (*Trachyspermum ammi* L.) germplasm under Udaipur agro-climatic conditions. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

5. Bairwa M, Meena SS and Mehta RS (2012) Productivity of fenugreek (*Trigonella foenum-graecum* L.) as influenced by bio-fertilizers and plant growth regulators. *5th Indian Horticulture Congress*, *"Horticulture for Food and Environment Security" held* at PAU, Ludhiana, Punjab, India from Nov 6-9, 2012

6. Lal G, Singh B, Singh R, Mehta RS and Maheria SP (2013) Off-Season cultivation of coriander in different protected structures. *National Seminar on Advances in protected cultivation, organized by Indian Society for Protected Cultivation at NASC, New Delhi on March 21, 2013.*

7. Gurjar R, Ranjan JK, Rathore SS and Agarwal KB (2013) Study of physiological and biochemical properties of coriander (*Coriandrum sativum* L.). *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, ISSS, Ajmer and DASD, Calicut at Jaipur from Feb 2-3, 2013.*

8. Kakani RK, Liu Y and Nair MG (2013) Assessment of variability in fenugreek (*Trigonella foenum-graecum*) genotypes based on antioxidant activity analysis. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

9. Kant K, Mishra BK, Vishal MK and Meena SR (2012) Eutromis Wasp (*Systole albipennis* Walker) in coriander: A pest of field and Quarantine significance and their management. *5th Indian Horticulture Congress, "Horticulture for Food and Environment Security" held at PAU, Ludhiana, Punjab, India from Nov 6-9, 2012.*

10. Kant K, Sharma YK, Lal G, Meena RD and Meena SR (2013) Feasibility of organic v/s chemical approach for aphids management in coriander: Impact on aphid population on crop and seed yield.*In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

11. Kant K, Sharma YK, Lal G, Meena RD, Vishal MK and Meena SR (2013) Impact of application methods of mntomopathogens for the control of aphids in cumin crop. . *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, ISSS, Ajmer and DASD, Calicut at Jaipur from Feb 2-3, 2013.*

12. Kant K, Singh B and Kumar NK (2013) Management of sucking pests of spice crops. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, ISSS, Ajmer and DASD, Calicut at Jaipur from Feb 2-3, 2013.*

13. Khan MA and Tripathi G K (2013) Seed spices one of the most remunerative crops in today's era: A comparative economic analysis. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

14. Lal G, Singh B, Singh R, Mehta RS, Maheria SP, Sharma Y and Parihar BR (2013) Effect of various protected structures and doses of nutrients on growth and yield attributes of cumin. *In : Book of National Seminar on Advances in protected cultivation, organized by Indian Society for Protected Cultivation at NASC, New Delhi on March 21, 2013.*

15. Lal G (2013) Post-harvest handling, processing and value addition of seed spices. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

16. Lal G, Kant K, Sharma Y and Barolia B (2013) Effect of different packaging material on post-harvest losses in coriander. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

17. Lal G, Mehta RS, Meena SS and Singh R (2012) Seed spices for livelihood security and socioeconomic development of farmers. *National Seminar on Horticulture for livelihood security, economic prosperity and sustainable development organized by Dept of HAMP, Mizoram University, Aizawl from September 24-26, 2012*

18. Lal G, Singh B, Mehta RS, Singh R, Kant K, Saxena SN and Maheria SP (2013) Protected cultivation of coriander: A profitable venture. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

19. Lal G, Singh R, Aishwath OP, Kant K, Saxena SN, Mehta RS, Maheria SP and Ram P (2013) Effect of iron and copper on growth and yield of fenugreek. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013*

20. Maheria SP, Lal G, and Mehta RS (2012) Modern tools of water management in seed spices. *National Seminar on Horticulture for livelihood security, economic prosperity and sustainable development organized by Dept of HAMP, Mizoram University, Aizawl from September 24-26, 2012*

21. Maheria SP, Lal G, Mehta RS and Singh R (2013) Enhancing water use efficiency in nigella (*Nigella sativa* L). *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013*

22. Maheria SP, Lal G, Mehta RS, Singh R and Singh B (2013) Mulching to improve water productivity in cumin. *National Seminar on Advances in protected cultivation, organized by Indian Society for Protected Cultivation at NASC, New Delhi on March 21, 2013*

23. Mehta RS, Malhotra SK, Meena SS, Lal G, Singh R, Sharma YK, Kant K and Khan MA (2012) Fennel (*Foeniculum vulgare* Mill.) based inter cropping system. *"Global Conference on Horticulture for Food, Nutrition and Livelihood Options*" held at Bhubaneshwar,Odisa, India from May 28-31, 2012

24. Mehta RS, Patel BS, Lal G, Singh R, Aishwath OP and Meena SS (2013) Yield and nutrient uptake of fenugreek (*Trigonella foenum-graecum* L) as influenced by nitrogen, phosphorus and bio-fertilizer. *In: Book of Abstracts of National Seminar on production, productivity & quality of seed spices, organized by NRCSS, Ajmer at Jaipur on Feb 2-3, 2013*

25. Meena RD, Sharma YK, Meena SS, Kant K, Mishra BK and Meena RS (2013) Management of wilt disease in cumin (*Cuminum cyminum* L.) through combination of soil solarization, neemcake and *Trichoderma. In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

26. Meena RL, Meena SS and Mehta RS (2013) Economic feasibility of weed management practices in ajwain. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

27. Meena RD, Sharma YK, Mishra BK, Meena SS, Meena RS, Lal G and Mehta RS (2012) Management of cumin wilts through soil solarisation. *"Global Conference on Horticulture for Food, Nutrition and Livelihood Options*" held at Bhubaneshwar, Odisha, on May 28-31, 2012

28. Meena RL, Meena SS, Mehta RS and Sharma DK (2013) Effect of weed management practices on growth and yield of nigella (*Nigella sativa* L.). *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

29. Meena SS, Bairva M and Mehta RS (2012) Productivity of fenugreek (*Trigonella foenum-graecum* L.) as influenced by bio-fertilizers and plant growth regulators. *Global Conference on Horticulture for Food, Nutrition and Livelihood Options held at Bhubaneswar, Odisha, India from May 28-31, 2012*

30. Meena SS, G Lal, Mehta RS and Singh R (2012) Productivity of anise (*Pimpinella anisum* L.) as influenced by agronomical practices. *National Seminar on Horticulture for livelihood security, economic prosperity and sustainable development organized by Dept of HAMP, Mizoram University, Aizawl from September 24-26, 2012.*

31. Meena SS, Meena RL and Mehta RS (2012) Economic feasibility of weed management practices in ajwain. *5th Indian Horticulture Congress, "Horticulture for Food and Environment Security" held at PAU, Ludhiana, Punjab, India from Nov 6-9, 2012*

32. Meena SS, Mehta RS and Lal G (2012) Influenced system productivity through inter cropping of seed spices with fruit crops. *5th Indian Horticulture Congress*, *"Horticulture for Food and Environment Security" held at PAU, Ludhiana, Punjab, India from Nov 6-9, 2012*

33. Meena SS, Mehta RS, Lal G and Singh B (2013) Effect of agronomic practices on profitability of dill (*Anethum sowa* L.). *In: Book of Abstracts of National Seminar on production, productivity & quality of seed spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

34. Meena SS, Solanki RK, Kakani RK and Kumari S (2012) Extent of genetic variability and character association in Ajwain. *National Seminar on Horticulture for livelihood security, economic prosperity and sustainable development organized by Dept of HAMP, Mizoram University, Aizawl from September 24-26, 2012.*

35. Mishra BK, Aishwath OP and Mehta RS (2013) Microbiological study of coriander (*Coriandrum sativum* L.) *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, at Jaipur from Feb 2-3, 2013.*

36. Naimuddin, Lal G, Aishwath OP and Singh B (2013) Performance of fenugreek with manures and *Rhizobium* inoculation. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, at Jaipur from Feb 2-3, 2013.*

37. Rathore SS, Saxena SN and Rajpurohit C (2012) Analysis of medicinally important compounds and anti-oxidant activity in oleoresin and volatile oil of fennel (*Foeniculum vulgare* Miller) genotypes. *Global Conference on Horticulture for Food, Nutrition and*

Livelihood Options held at Bhubaneswar, Odisha, India from May 28-31, 2012

38. Rathore SS, Saxena SN and Singh B (2012) Potential health benefits of major seed spices. *National seminar on Recent advances in botany held at Dyanand college, Ajmer from Dec 3-4, 2012*

39. Rathore SS, Saxena SN, Kakani RK, and Saxena R (2012) Study on genotypic variation in oleoresin and some antioxidant properties of fenugreek. In: Abstracts of the *5th Indian Horticulture Congress, "Horticulture for Food and Environment Security" held at PAU, Ludhiana, Punjab, India from Nov 6-9, 2012.*

40. Rathore SS, Saxena SN, Saxena R, Sharma L and Singh B (2013) Analysis of medicinal properties in coriander genotypes. *5th International conference on Medicinal plants & Herbal products held at Manipal College of Pharmaceutical Sciences, Manipal University, Manipal, Uddupi from January, 25-27, 2013*

41. Rathore SS, Saxena SN, Sharma YK and Saxena R (2013) Effect of natural antioxidants on control of wilt disease and expression of defense related molecules. *In: Book of Abstracts of National Seminar on production, productivity & quality of seed spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

42. Agrawal KB, Ranjan JK, Rathore SS, Saxena SN and Mishra BK (2013) Analysis of physical and biochemical properties of fenugreek (*Trigonella sp.* L.) leaf during different growth stage. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

43. Rathore SS, Saxena SN, Sharma YK and Sharma L (2013) Effect of pH and NaCl salinity on growth of *Fuserium oxysporium* f.sp. *cumini*. *In: Book of Abstracts of National Seminar on production, productivity & quality of seed spices, organized by NRCSS, Ajmer, at Jaipur from Feb 2-3, 2013.*

44. Saxena SN, Lal G, Kakani RK, Rathore SS, Meena RS and Singh B (2012) Effect of water stress on morpho-physiological parameters of coriander (*Coriandrum sativum* L.). *In symposium on Managing stress in drylands under climate change scenarios held at CAZRI, Jodhpur from Dec 1-2, 2012.*

45. Saxena SN, Lal G, Kakani RK, Rathore SS, Meena RS and Singh B (2012) Sustainable management strategies under changing climate. *In symposium on Managing stress in drylands under climate change scenarios held at CAZRI, Jodhpur from Dec 1-2, 2012.*

46. Saxena SN, Rathore SS, Saxena R and Kakani RK (2013) Photosynthetic parameters in seed spice crops *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

47. Saxena SN, Rathore SS, Saxena R and Kakani RK (2013) Physiological parameters and their relation to seed yield in seed spice crops. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

48. Saxena, SN, Rathore, S.S., Barnwal, P., Saxena, R and Sharma, L (2012). Effect of cryogenic grinding on recovery of diosgenin content in fenugreek (*Trigonella foenum-greacum)* genotypes. In: Abstracts of the *5th Indian Horticulture Congress, "Horticulture for Food and Environment Security" held at PAU, Ludhiana, Punjab, India from Nov 6-9, 2012.*

49. Sharma YK, Kakani RK and Ridhishanker (2013) Characterization of fenugreek lines for powdery mildew reaction. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, ISSS, Ajmer and DASD, Calicut at Jaipur from Feb 2-3, 2013.*

50. Sharma YK, Kakani RK, Kant K, Meena RD and Saxena SN (2013) Efficacy of oxystrobin 25 SC on cumin blight caused by *Alternaria burnsii. In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

51. Sharma YK, Lal G, Kant K and Mehta RS (2013) Standardization of disease management practices for root rot and powdery mildew diseases in fenugreek. *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

52. Singh PP, Naruka IS, Rathore SS and Kushwah SS (2013) Genetic variability and path analysis in fenugreek (*Trigonella foenum-greacum*). *In: Book of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer at Jaipur from Feb 2-3, 2013.*

53. Singh R, Lal G, Maheria SP, Choudhary S, Mehta RS, and Singh B (2012). Effect of irrigatiuon techniques and planting methods on yield and water productivity in cumin. *In Extended Summaries Vol 3: 3rd International Agronomy Congress Novemeber 26-30, 2012, New Delhi* pp 926-926

54. Singh R, Lal G, Mehta RS, Aishwath OP, and Choudhary S (2012). Identification of critical stage for weed management in cumin (*Cuminum cyminum* L.). *In proceedings of 5th Indian Horticulture Congress-2012 held at PAU, Ludhiana from Nov 6-9, 2012* pp 363-364.

55. Singh R and Singh B (2013). Application of drip fertigation and plastic mulching in seed spice cultivation. *In proceedings of National Seminar on Advances in Protected Cultivation" held at New Delhi* on March, 21 2013

56. Singh R, Lal G, Choudhary S and Singh B (2013). Yield losses due to weeds in fenugreek and critical stage for weed competition. *In book of Abstracts of National Seminar on Production, productivity and quality of spices* held from February, 2-3, 2013 at Jaipur.

57. Singh R, Lal G, Maheria SP, Choudhary S, Mehta RS and Godara AS (2012). Effect of irrigation methods and land configuration on yield and water productivity of Kassuri methi in India. *In proceedings of "Global conference on horticulture for food, nutrition and livelihood options" held at Bhubaneshwar, Odisha, India* from May 28-31, 2012

58. Singh B and Singh R (2012). Efficient use of water in agriculture and rain water harvesting. *In proceedings of 16th Annual conference of Indian Political Economy Association held from October 26-27, 2012 at IIT, Roorkee*

59. Singh B and Singh R (2013). Opportunities of plug tray nursery raising and transplanting in seed spices. *In proceedings of National Seminar on Advances in Protected Cultivation" held at New Delhi* on March, 21 2013

60. Godara A S, Gupta US, Singh R and Singh SP (2013). Response of fenugreek (*Trigonella foenum-graecum*) to integrated nutrient management. *In book of Abstracts of National Seminar on Production, productivity and quality of Spices held from February, 2-3, 2013 at Jaipur.*

61. Singh B and Saxena SN (2012) Seed Spices: Sustainable management strategies under changing climate. *In symposium on Managing stress in drylands under climate change scenarios held at CAZRI, Jodhpur from Dec 1-2, 2012.*

62. Verma M, Kakani R, Rathore SS, Saxena R, Sharma L and Saxena SN (2013) Analysis of medicinally important compounds and antioxidants properties of Anise (*Pimpinella anisum*) seed extract and shoot callus. *In: Book*

of Abstracts of National Seminar on production, productivity & quality of spices, organized by NRCSS, Ajmer, at Jaipur from Feb 2-3, 2013.

63. Vishal MK, Lal G, Mehta RS, Mishra BK, Ranjan JK and Choudhary S (2012). Emerging export potential of Seed Spices vis-à-vis Spices in Indian horticulture, *In: Abstracts of the Fifth Indian Horticulture Congress – 2012 held during Nov 6-9, 2012, at PAU, Ludhiana, India.*

64. Vishal MK, Obi Reddy GP, Singh R., Aishwath OP, Mehta RS, Mishra BK, and Kumar N. (2013). Spatial and temporal assessment of area, production and productivity scenarios of cumin in Rajasthan. *In: Book of Abstracts, National Seminar on Production, Productivity and Quality of Spices held during 2-3 February 2013, at Jaipur, India.*

65. [kku ,e , cyjkt flg ,o th d f=ikBh chth; elyk Qly mxk, vkj vf/kd ykHk dek,A elyk mRikn d"kd euvy 2013 mUur chth; elyk ,o df"k mRiknu ik|kfxfd;kA idk'kd % jk"Vh; chth; elyk vul/kku ØUn] vtej

Publications Other than seed spices

1. Aishwath OP (2012) Response of medicinal plants to zinc. *Indian Journal of Fertilizers* 8(5): 14-20
2. Chaturvedi S, Kumar A, Singh B, Nain L, Joshi M and Satya S (2012) Bioaugmented composting of *Jatropha* de-oiled cake and vegetable waste under aerobic and partial anaerobic conditions. *Journal of Basic Microbiology* 52: 1-9
3. Choudhary S and Choudhary M (2013) Scrapie: A neuro degenerative disease in Sheep- A review. *Agricultural Reviews* 34(1): 77-83
4. Choudhary S, Gupta N and Gupta SC (2012) Identification of SNPs in PRNP gene in Karnah sheep breed of India. *Indian Journal of Animal Sciences* 82(6): 609–614
5. Haldar A, Naruka IS, Singh PP and Rathore SS (2012) Effect of antioxidants on growth, yield and quality of garlic (*Allium sativum* L.). *Medicinal Plants* 4(4):206-11
6. Jain NK, Mishra BK and Sharma KC (2012) Comparative studies of different drying methods on the quality indices of maize and groundnut seeds. *Proceedings of National Seminar on Power Generation from Renewable Energy Sources* (Eds. Rathore *et al*.), MPUAT, Udaipur pp : 280-283
7. Jat RA, Tandel A, Patel B, T.U. and Mehta RS **(**2012) Response of saline water irrigated green gram (*Vigna radiata*) to land configuration, fertilizers and farm yard manure in Tapi command area of South Gujarat. *Indian Journal of Agronomy* 57(3):93-97
8. Kaur C, Walia S, Nagal S, Walia S, Singh J, Singh BB, Saha SP, Singh B, Kalia P, Jaggi S and Sarika (2013) Functional quality and antioxidant composition of selected tomato (*Solanum lycopersicon* L) cultivars grown in Northern India. *Food Science and Technology* (LWT) 50: 139 145
9. Kumar R, Kaul MK, Saxena SN**,** Bhargava S and Singh S (2012) Protocol standardization for micropropagation of *Citrus jambhiri* Lush. using nodal segments of nucellar seedlings. *Progressive Horticulture* 44(1): 101-109
10. Kumar S, Jain NK, Sharma KC, Mishra BK, Srinivasan R and Paswan R (2012) Pectinolytic profile of some fungal strains. *Journal of Mycololgy and Plant Patholology* 42(2): 213-217
11. Mishra BK and Nain L (2013) Microbial activity during rice straw composting under coinoculation of *Cellulomonas cellulans* and *Phanerochaete chrysosporium*. *International Journal of ChemTech Research* 5(2): 795-801
12. Patil T, Singh M, Singh B, Khanna M, Singh DK and Parihar SS (2012) Influence of irrigation interval, nitrogen level and crop geometry on production of trickle irrigated lettuce. *Indian Journal of Horticulture* 69(3): 360 -366

13. Pendre NK, Nema PK, Sharma HP, Rathore SS and Kushwah SS (2012) Effect of drying temperature and slice size on quality of dried okra (*Abelmoschus Esculentus* (L.) Moench). *Journal of food science and Technology* 49(3): 378-381
14. Ranjan JK, Ahmed N, Das B, Ranjan P and Mishra BK (2013) Green technology for production of baby corn (*Zea mays* L) under North-West Himalayan conditions. *International Journal of ChemTech Research* 5(2): 880-85
15. Ranjan P, Ranjan JK, Das B and Ahmed N (2013) High value flower cultivation under low cost greenhouse in North-West Himalayas. *International Journal of ChemTech Research* 5(2): 779-94
16. Sabir N and Singh B (2013). Protected cultivation of vegetables in global arena: A review. *Indian Journal of Agricultural Sciences* 83(2):123-135
17. Singh B, Singh R and Singh R (2012) Improving water and nutrient use efficiency through fertigation. *Indian Journal of Fertilizers* 8(11): 94-103
18. Singh R, Malik J K, Thenua OVS and Jat HS (2013) Effect of phosphorus and bio-fertilizer on productivity, nutrient uptake and economics of pigeonpea (*Cajanus cajan*) & mungbean (*phaseolus radiatus*) intercropping system. *Legume research* 36 (1): 41-48.

Book Chapters

1. Ranjan JK, Ranjan P, Mishra BK, Kant K and Vishal MK (2013) Energy efficient greenhouses for vegetable cultivation in NW Himalayas. *In Global scenario in environment and energy (Eds: Suresh S and Sudhakar K) BS Publications, Hyderabad.* pp: 276-286

Popular articles

1. Hasan M, Singh B, Kaore SV, Tarunendu and Naved S (2012) Fertigation scheduling of crops. *Indian Farming* 62(4): 41-46
2. Hasan M, Singh B, Kaore SV, Tarunendu and Naved S (2012). Fertigation scheduling for horticultural crops. *Indian Farming* 62(5): 41-46
3. Jain NK and Mishra BK (2012) *Sitaphal ke prasanskrit utpad*. *Rajasthan kheti pratap (December issue), MPUAT, Udaipur*. pp: 27-28
4. Ranjan JK, Mishra BK, Rathore SS, Pragya and Kant K (2013) *Rajasthan me lahsun utpadan kee vyagyanik vidhi.* In *Beejiya Masala Surabhi. Published by Director, NRCSS, Ajmer* pp: 99-101
5. Singh B (2012) Seed Production of summer squash in North Indian plains. ICAR News 18(2): 14
6. Singh B and Hasan M (2011) *Safalta kee kahani: kam dab sinchai parnali. Krishi Vistar Sameeksha* 21(2):11-12
7. Singh B and Singh R (2013) Zaid mein sabjiyon ke utpadan hetu adhunik prodyogikiyan. *Khad Patrika* 54(3):20-24
8. Singh B, Rajkumar and Rani S (2012) *Greenhouse mein tamatar utpadan prodyogiki. Prasar Doot* 16(5):24-27
9. Singh B, Singh A and Kumar M (2012) *Perinagriye chetron main: Aisi hogi sabjiyon ki sanrakshit kheti*. *Phal Phool* 33 (3): 3-6
10. Singh B, Walia S, Rani S, Kumar M and Singh A (2012) Get nutrition from garden at your home. *Indian Horticulture* 57(4):24-27

11. RAC/IMC/IRC Meetings

11.1 RAC Meetings (X & XI)

X Research Advisory Committee meeting of the centre was conducted on 14th April, 2012. Recommendations made during the 2012 RAC meeting were approved by the council and action taken report was presented in XI RAC meeting conducted during 14-15th March, 2013 where in , all the members of RAC including the chairman Dr V A Parthasarthy, Former Director IISR, Calicut, Director and scientists of NRCSS, Ajmer were present. Theme wise presentations were made by different programme leaders. Following recommendations were made by XI RAC which have been approved by the council.

1. After completion of the projects precise recommendations should be included in the Package of Practices.
2. RAC Members can also be invited in IRC meeting.
3. The Directorate of Extension Education of SAU may be informed for inclusion of the Package of Practices released by NRCSS.
4. Proposal for inclusion of Ajwain in AICRP on Spices for varietal evaluation may be taken up with PC, AICRP by considering its upcoming importance like major seed spices.
5. All the patentable issues may be reported in ITMC and accordingly informed in IRC/RAC.
6. NRCSS logo can be registered with Registrar of Trade Marks.
7. Germplasm collected by NBPGR and its sub-centres should be procured for NAGS at NRCSS.
8. Only those germplasm collected by different AICRPS centers along with passport data having the IC numbers may be included in NAGS through PC, AICRP on Spices.
9. Proposal for release of AFg-3 should be submitted for national release and notification.
10. New gametocides should be taken and selected on the basis of published literature.
11. Celery and caraway projects should be shifted and merged with germplasm evaluation project.
12. Basic soil fertility status should be considered for deciding dose of fertilizers.
13. Observation on disease and pests incidence should be recorded in different irrigation system research.
14. Any recommendation related to cropping sequence may be communicated to respective crop Institute for better popularization.
15. Recommendation for post harvest packaging practices should be separate for seed and for commercial produce.
16. In the new project on edaphic stresses and nutrient management studies, the scientist may concentrates on edaphic stress alone.
17. WTO guidelines should be referred for conducting survey of disease and pests.
18. Low doses of Mencozeb may be tested for effective disease control with permitted MRL.
19. As indicated in the last RAC, identification of seed midge should be done at the earliest taking help of IISR entomologist.

20. Stepwise correlation and multiple correlations may be done of physiological parameters for precise interpretation of the results for publication.
21. Market analysis may be undertaken in collaboration with other institute and agencies located in Rajasthan or after economics scientist is posted.
22. Techno-economical feasibility of the major developed technologies of the institute may be worked out.
23. Impact analysis of the technologies may also be taken up after economics scientist is posted.

RAC members

Name	Position
Dr. V. A. Parthasarathy	Chairman
Dr. S. B. S. Tikka	Member
Dr. A. K. Srivastava	Member
Dr. S. R. Bhatt	Member
Dr. M. N. Khare	Member
Dr. Umesh Srivastava	Ex Officio Member
Dr. Balraj Singh	Ex Officio-Member
Dr. Rajesh Kumar Kakani	Member Secretary

11.2 IMC Meeting

X IMC meeting was held on 14 Aug, 2012. The meeting was chaired by Dr Gopal Lal, Director (Act), NRCSS and other members. A brief introduction of ongoing research activities were made before the committee. Sh Ravindra Singh, Member Secretary presented the report as per the agenda items. Six agenda items were discussed and recommended by IMC. The council has approved the proceedings of IMC on 02.11.2012.

IMC Members

Name	Position
Dr. Gopal Lal	Chairman
Dr. A.K.Srivastava	Member
Dr. Neelima Garg	Member
Dr. P. Chowdappa	Member
Dr. K. Nirmal Babu	Ex Officio Member
ADG (H-II), New Delhi	Ex Officio Member
Director of Horticulture, Govt of Gujrat	Ex Officio-Member
Director, Research, SKRAU, Bikaner	Ex Officio-Member
FAO, Directorate of Mustard Research, Bharatpur	Ex Officio-Member
Sh. Ravindra Singh	Member Secretary

11.3 IRC Meeting

12th Institute Research Council Meeting was held on September 15-17, 2012 under the chairmanship of Dr. Balraj Singh, Director, NRCSS. Salient achievement of ongoing projects were presented by the concerned project incharge and discussed in length. The chairman reviewed the research achievements of each project and gave critical input for refinement of the research programmes. Number of projects was restructured in 17 programs by merging projects of similar nature. Technical programme of new project proposal were also discussed thoroughly on October 25-26, 2012.

Crop Improvement

1. **Collection, evaluation and documentation of plant genetic resources of seed spices**
   Project Leader : Dr. R. K. Solanki
2. **Breeding for improvement in major seed spices**
   Project Leader : Dr R. K. Kakani and Dr. R. S. Meena
3. **Breeding for improvement in minor seed spices**
   Project Leader : Dr. S.S. Meena
4. **Deciphering molecular diversity and molecular characterization in seed spices**
   Project Leader : Dr. Sharda Choudhary
5. **Basic and applied studies on artificial hybridization in major seed spices**
   Project Leader : Dr. J.K. Ranjan

Crop Production

6. **Post Harvest management and value addition in Seed Spices**
   Project Leader : Dr. G. Lal
7. **Precision farming in seed spices**
   Project Leader : Dr. Ravindra Singh
8. **Cropping system and weed management in seed spices**
   Project Leader : Dr. R.S. Mehta
9. **Assessment of edaphic stresses and nutrient management for sustainable seed spices**
   Project Leader : Dr. O. P. Aishwath
10. **Microbiological approaches in integrated nutrient management in seed spices**
    Project Leader : Dr. B.K. Mishra

Crop Protection

11. **Survey & surveillance of existing and emerging diseases and insect pests in seed spices**
    Project Leader : Dr. R. D. Meena
12. **Management of insect pests in seed spices**
    Project Leader : Dr. Krishna Kant
13. **Management of diseases in seed spices**
    Project Leader : Dr. Y.K. Sharma

Basic Science

14. **Physiological approaches for enhancing yield and quality in seed spices under abiotic stresses**
    Project Leader : Dr. S. N. Saxena
15. **Biochemical basis of defence mechanism and quality traits in seed spices**
    Project Leader : Dr. S. S. Rathore

Social Science

16. **Seed spices knowledge management and technology transfer**
    Project Leader : Sh. M. K. Vishal

12. Training/Refresher Course/ Summer / Winter Schools/ Seminars/Conferences/ Symposia/ Workshop Attended by the Scientists

12.1 Training (International):

S.No.	Name of the participant	Name of the Training Programme/ Venue	Period
1.	Dr.R.S. Mehta	Sensor Based Application including Bio indicators at Cropping System and Quality Research Unit, 269, Agricultural Engineering Building, University of Missouri, Columbia, Missouri, USA.	Sep 04 to Dec 02, 2012 (90 days)
2.	Dr. J. K. Ranjan	Marker Assisted Selection in Horticultural Crops at Institute of Nutraceutical, Clemson University, South Carolina, USA	Aug 15 to Nov 12, 2012 (90 Days)

12.2 Training (National):

S.No.	Name of the participant	Name of the Training Programme/ Venue	Period
1.	Dr. Balraj Singh	Executive Development Programmes for Directors of ICAR at NAARM, Hyderbad	17-21 Dec , 2012
2.	Dr. G. Lal	M.D.P. on Leadership Development at NAARM, Hyderabad	08-19 Oct, 2012
3	Dr. S. S. Rathore	Agricultural Research Management for newly recruited Senior/Principal Scientists of non-ARS stream of ICAR, NAARM, Hyderabad.	5-18 June, 2012
4.	Dr. B. K. Mishra	TDP-Right to Information Act 2005 at Institute of Secretariat Training & Management (Department of Personnel and Training, Govt. of India) Old JNU Campus, New Delhi.	15-19 Oct, 2012
5.	Dr. R. D. Meena	Resource Conservation Technologies for Seed Spices held at NRC on Seed Spices, Ajmer	18-25 Jan, 2013
6.	Sh Mukesh Kumar Vishal	Forecast Modelling in Crops held at IASRI, New Delhi	17 July - 6 Aug, 2012
		Resource Conservation Technologies for Seed Spices held at NRC on Seed Spices, Ajmer	18-25 Jan, 2013
		Capacity Building Workshop on Agropedia and Open Access Institutional Repository organized at ICRISAT, Patancheru, Andhra Pradesh	11-12 March, 2013

12.3 Conference / Seminar / Symposia / Workshop / Meetings

S.No.	Name of the participant	Name of the Conference/Seminar / Symposia / Workshop/ Meetings/Venue	Period
1.	Dr. Balraj Singh	AICRP work shop on spices held at IISR, Calicut	30 Sep-Oct 2, 2012
		Invited speaker in Global Agriconnect- 2012 held at IARI, New Delhi	2-4 Nov, 2012
		Invited/lead speaker in the 5th Indian Horticultural Congress held at PAU, Ludhiana	6 – 9 Nov, 2012
		ICAR-Regional committee meeting at CAZRI Jodhpur	16-17 Nov, 2012
		Invited speaker in National Symposia on Managing Stresses in Dryland under Climate Change Scenario organized at CAZRI, Jodhpur	1-2 Dec, 2012
		National Seminar on Recent Advances in Botany as key note speaker held at Dayanand College, Ajmer	3 Dec, 2012
		Invited/lead speaker in the 100th Indian Science Congress held at University of Calcutta, Kolkata	3-8 Jan, 2013
		Meeting on working group of Agriculture for Rajasthan State at Jaipur	1 Feb, 2013
		Invited/lead speaker in National Organizing Committee for National Seminar on Production, Productivity and Quality of Spices held at Jaipur	2-3 Feb, 2013
		Invited speaker in Horti-India 2013 held at Noida, New Delhi	16-17 Feb, 2013
		National Workshop organised for ICAR Young Scientist at NASC Complex, PUSA -New Delhi	1-2 March, 2013
		National Seminar on Advances in Protected Cultivation held at NASC Complex, New Delhi	21 March, 2013
2.	Dr. G. Lal	Study Visit to Texas A&M University, USA to aquint with state of art technique in post harvest management of horticultural crops.	4-17 June, 2012
		National Seminar on Production, Productivity and Quality of Spices, held at at Panchayatiraj Bhawan, JLN Marg, Jaipur	2-3 Feb, 2013
		National Seminar on Advances in Protected Cultivation. Organized by Indian Society for Protected Cultivation, CPCT, IARI, New Delhi	21 March, 2013
		National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development at Mizoram University, Aizawl, Mizoram	24-26 Sep, 2012
3.	Dr. S. N. Saxena	IFT Annual meeting and Food Expo-2012 organized by Institute of Food Technologists, Chicago at Convention Centre, Las Vegas, Nevada, USA	25-28 June, 2012
		5th IHC-2012 held at PAU, Ludhiana.	6-9 Nov, 2012
		Managing Stress in Dry Lands Under Climate Change Scenarios held at CAZRI, Jodhpur	1-2 Dec, 2012
		National seminar on Production, productivity and Quality of Spices held at Jaipur	2-3 Feb, 2013
		CIC/CAC meeting of NAIP project “Cryogenic grinding for retention of flavour and medicinal properties in some Indian spices” held at IASRI, New Delhi.	8 Mar, 2013
4.	Dr. R. K. Kakani	National Seminar on “Horticulture for Livelihood Security, Economic Prosperity and Sustainable development” at Mizoram University, Aizawl	24-26 Sep, 2012
		XXIII Workshop of All India Coordinated Research Project on Spices held at IISR, Calicut	29 Sep -2 Oct, 2012
		National Consultation on Management of Horticultural Genetic Resources at NBPGR, New Delhi	18-19 Dec, 2012
		National Seminar on Production, Productivity and Quality of Spices held at Jaipur organized by NRCSS, Ajmer.	2-3 Jan, 2013
		Task Force Meeting to evaluate and finalize test guidelines for seed spices (coriander and fenugreek) at NRCSS, Ajmer.	11 Mar, 2013
5.	Dr. Y. K. Sharma	National Seminar on Production, Productivity and Quality of Spices held at Jaipur organized by NRCSS, Ajmer	2-3 Feb, 2013
		Annual Review Meeting of CSS under NHM held at GKVK, Bangalore,	18-19 July, 2012

S.No.	Name of the participant	Name of the Conference/Seminar / Symposia / Workshop/ Meetings/Venue	Period
6.	Dr.R.S. Mehta	The 5th IFIP World IT Forum (WITFOR 2012) held at Vigyan Bhavan, New Delhi, India	16 – 18 Apr, 2012
		Global Conference on Horticulture for Food, Nutrition and Livelihood Options held at Bhubaneshwar, Odisha, India	28-31 May, 2012
		National Seminar on Production, Productivity and Quality of Spices, held at Panchayatiraj Bhawan, JLN, Marg, Jaipur	2-3 Feb, 2013
		Workshop on Translating Missouri USDA-ARS Research and Technology into Practice" at the Bradford Farm Conference Center, University of Missouiri, USA.	10-11 Oct, 2012
		Annual International meeting of ASA, CSSA and SSSA held at Duke Energy Convention Centre, Cincinnati, OH, USA.	22-24 Oct, 2012
		2012 Mizzou Diversity Summit held at Memorial Union , University of Missouri, Columbia, USA	29-30 Oct, 2012
		National Seminar on Advances in Protected Cultivation held at NASC, complex, New Delhi	21 Mar, 2013
7.	Dr. Ravindra Singh	Meeting on "Indian Spices best for export" held at PHD House, New Delhi	7 June, 2012
		Meeting of Task Force Committee on Seed Spices held at Cochin	15 June, 2012
		5th Indian Horticulture Congress, An International Meet held at Punjab Agriculture University, Ludhiana	6-9 Nov, 2012
		3rd International Agronomy Congress held at New Delhi	26-30 Nov, 2012
		National Seminar on Production, Productivity and Quality of Spices, held at Jaipur, Rajasthan.	2-3 Feb, 2013
		Workshop on "Targeting climate resilient agricultural technologies in arid western Rajasthan" held at CAZRI, Jodhpur	14-15 March, 2013
		Advances in Protected Cultivation held at New Delhi	21 March, 2013

S.No.	Name of the participant	Name of the Conference/Seminar / Symposia / Workshop/ Meetings/Venue	Period
8.	Dr. O. P. Aishwath	Global Conference on Horticulture for Food, Nutrition and Livelihood Options, held at Bhubaneswar, Odisha.	28-31 May, 2012
		National Symposium on Innovative Approaches and Modern Technologies for Crop Productivity, Food Safety and Environmental Sustainability, held at Thrissur, Kerala.	19-20 Nov, 2012
		77th Annual Convention of Indian Society of Soil Science held at Ludhiana	3-6 Dec, 2012
		National Seminar on Production, Productivity and Quality of Spices, held at Jaipur, Rajasthan.	2-3 Feb, 2013
9.	Dr. Krishna Kant	5th Indian Horticulture Congress, An International Meet held at Punjab Agriculture University, Ludhiana	6-9 Nov, 2012
		National Seminar on Production, Productivity & Quality of Spices held at Jaipur.	2-3 Feb 2013
10.	Dr. S. S. Meena	Global Conference on Horticulture for Food, Nutrition and Livelihood Options held at Bhubaneswar, Odisha, India	28-31 May, 2012
		National Seminar on Horticulture for Livelihood Security, Economic Prosperity & Sustainable Development held at Mizoram University, Aizawl, Mizoram, India.	24-26 Sep, 2012
		5th Indian Horticulture Congress, An International Meet on "Horticulture for Food and Environment Security held at PAU, Ludhiana.	6-9 Nov, 2012
		National Seminar on Production, Productivity and Quality of Spices, held at Jaipur	2-3, Feb 2013
11.	Dr. J. K. Ranjan	International Conference on Global Scenario in Environment and Energy (ICGSEE 2013) held at MANIT Bhopal, India	14-16 Mar 2013
		Global Conference on Horticulture for Food, Nutrition and Livelihood Option held at OUAT, Bhubaneswar, Odisha	28-31May, 2012
		5th IFIP World IT Forum (WITFOR 2012) held at Vigyan Bhavan, New Delhi, India	16 -18 Apr, 2012

S.No.	Name of the participant	Name of the Conference/Seminar / Symposia / Workshop/ Meetings/Venue	Period
		National Seminar on Production, Productivity and Quality of Spices held at Jaipur	2-3 Feb, 2013
		National Workshop on Foresight and Future Pathways of Agricultural Research through Youth in India held at NASC Complex, New Delhi	1-2 Mar, 2013
12.	Dr. S. S. Rathore	The 5th IFIP World IT Forum (WITFOR 2012) held at Vigyan Bhavan, New Delhi	16 – 18 Apr 2012.
		National Seminar on “Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development” held at Mizoram University, Aizawl	24-26 Sep, 2012
		5th IHC-2012 held at PAU, Ludhiana.	6-9 Nov, 2012
		National Seminar on “Green Chemistry” held at Dayanand College, Ajmer	29-30 Nov, 2012
		Managing Stress in Dry Lands Under Climate Change Scenarios held at CAZRI, Jodhpur	1-2 Dec, 2012
		National Seminar “Recent Advances in Botany” held at Dayanand College, Ajmer	3-4 Dec, 2012
		1st International conference on Innovation in Food Processing, Value Chain Management and Food safety held at NIFTEM, Kundli, Sonipat.	10-11 Jan, 2013
		Workshop on Food Safety held at NIFTEM, Sonipat	12 Jan, 2013
		National Seminar on Production, Productivity and Quality of Spices held at Jaipur	2-3 Feb, 2013
		CIC/CAC meeting of NAIP project Cryogenic grinding for retention of flavour and medicinal properties in some Indian spices held at IASRI, New Delhi	8 Mar, 2013
13.	Dr. B. K. Mishra	5th IFIP World IT Forum (WITFOR 2012) at Vigyan Bhavan, New Delhi, India	26-18 Apr, 2012
		5th Indian Horticulture Congress-2012 at Punjab Agricultural University, Ludhiana, India	6 -9 Nov, 2012
		6th DBT Task force meeting on Biological agents for Agriculture at TERI southern regional station, Bangalore	28 Oct, 2012

S.No.	Name of the participant	Name of the Conference/Seminar / Symposia / Workshop/ Meetings/Venue	Period
		International Conference on Global Scenario in Environment and Energy (ICGSEE 2013) at MANIT, Bhopal, India	14 -16 Mar, 2013
14.	Dr. R. S. Meena	National Seminar on Production, Productivity and Quality of Spices held at Jaipur	2-3 Feb, 2013
15.	Dr. Sharda Choudhary	World Congress on Biotechnology held at Leonia International Convention Centre, Hyderabad, India	4-6 May 2012
		The 5th IFIP, World IT Forum, WITFOR 2012, held at Vigyan Bhawan, New Delhi	16-18 Apr 2012
		Indian Horticulture Congress-2012 held at PAU, Ludhiana, Punjab, India	6-9 Nov 2012
		National Seminar on “Production, Productivity and Quality of Spices held at Jaipur, Rajasthan	2-3 Feb 2013
16.	Dr. R. D. Meena	National Seminar on Production, Productivity and Quality of Spices, held at Jaipur, Rajasthan	2-3 Feb, 2013
17.	Sh. Mukesh Kumar Vishal	The 5th IFIP World IT Forum (WITFOR 2012) held at Vigyan Bhavan, New Delhi	26-18 Apr, 2012
		Indian Horticulture Congress-2012 held at PAU, Ludhiana, Punjab, India	6-9 Nov, 2012
		National Seminar on Production, Productivity and Quality of Spices held at Jaipur, Rajasthan	2-3 Feb, 2013
18.	Sh. S. P. Maheria	National Seminar on Production, Productivity and Quality of Spices held at Jaipur, Rajasthan	2-3 Feb, 2013
		National Seminar on Horticulture for Livelihood Security, Economic Prosperity and Sustainable Development held at Mizoram University, Aizawl	24-26 Sep, 2012
		National Seminar on Advances in Protected Cultivation held at CPCT, IARI, New Delhi	21 March, 2013
19.	Sh. M.A. Khan	Challenges and opportunities for public private partnership in Rape Seed & Mustard Research and Development at DRMR Bharatpur	29 Sep, 2012
		3rd International Agronomy Congress held at IARI, Pusa, New Delhi	26-30 Nov, 2012
		National seminar on Production, Productivity and Quality of Spices held at Jaipur	2-3 Feb, 2013

13. Training/Refresher Course/ Summer / Winter Schools/ Seminars/Conferences/ Symposia/ Workshop Organized at the Centre

13.1 National Seminar on "Production, Productivity and Quality of Spices" at Jaipur

National Seminar on" Production, Productivity and Quality of Spices" was organized at Panchayti Raj Bhavan, Jaipur by National Research Centre on Seed Spices, Ajmer. The inaugural programme was chaired by Padma Bhusan Dr. R. S. Paroda, Chairman Haryana Kisan Ayog. The other dignitaries were Dr. S.A. Patil (Chairman Karnataka Farmers Mission), Dr. O.P. Gill (VC, MPUAT), Dr. Tamil Selvan (Ad. Diector, NHM) and Dr. Umesh Srivastava, ADG (Hort). In inaugural address Dr. Paroda said about the need of "Think globally and act locally". He stressed upon adopting improved cultivation practices. Dr. Patil told that just by policy reorientation India can feed another India. Dr. Selvan explained the status of spice production and export.

The seminar was attended by various scientists across the country along with industrialist, processors, farmers and students. A thorough discussion happened on crop improvement, crop production and protection technologies. Dr. Balraj Singh, Director, NRCSS emphasised on the adoption of improved varieties, better production technologies like raised bed planting with drip and sprinkler fertigation system. Techniques of seed priming and pelleting have high potential if applied in seed spices, he also explained the sensitization for Good

Agricultural Practices (GAP) in seed spices. A innovative farmer coming from Gujarat was motivated by awarding a appreciation certificate for his valuable invention of solar driven Knapsack sprayer. On the occasion 4th Issue of International Journals of Seed Spices published by ISSS, Ajmer and two books 'Good Agricultural Packaging Practices' and 'Spices Fragrance' were also released. The Indian Society of Seed Spices, Ajmer admitted Dr. S.K Dubey, Dr. J.K Ranjan, Dr. Ravindra Singh, Dr. S.S Rathore and Dr. B.K Misra as fellow of the society for their significant contribution in the research and development of seed spices.

Modal Training Course on "Resource conservation techniques and micro-irrigation for precision input application in seed spices"

The objective of this training was to update the knowledge and improve the skill of participants on RCTS and Micro irrigation for sustainable seed spice production. 25 participants comprising officials/ teachers/ scientist from State Development Agencies, ICAR Institutes/ SAUs from Kerala, Gujarat, Odisha and Rajasthan attended the training. During 8 days of training different aspects of RCTs include a wide range of practices: No-till / minimum tillage approaches or reduction in tillage operations, were covered and participants seen all these aspects practically at NRCSS fields as well as farmers field.

Training Programme conducted at NRCSS for farmers

S.No.	Training programme	Duration	No. of farmers
1.	chth; elyk dh mRikndrk ,o x.koÙkk of) gr vk/kfud rduhfd;k	5-8 March, 2013	30
2.	Programme on Advance Production Technology of Seed Spices	7-8 Feb, 2013.	50
3.	Advance seed spices and agricultural production technologies	29 Oct to 2 Nov, 2012	30
4.	Advance seed spices and agricultural production technologies	3-7 Nov, 2012	30
5.	chth; elyk fdlkuk d fy, mRiknu dh uohure rduhfd;k	13-17 Jan, 2013	30
6.	uohure chth; elyk mRiknu rduhd	8-12 Jan, 2013	30

14. Distinguished Visitors

S.No.	Name and address	Date
1.	Dr. R. S. Paroda Chairman, Haryana Kissan Aayog & Former Director General, ICAR	10.08.2012
2.	Dr A. K. Singh DDG, NRM, ICAR	10.08.2012
3.	Shri Jagroop Singh Director, Directorate of Horticulture, Govt. of Rajasthan	14.08.2012
4.	Dr. M. Mahadevappa, Ex-Chairman, ASRB & former Vice Chancellor of University of Agricultural Sciences, Dharwad	09.10.2012
5.	Mr. Shawkat Momen Shahjahan, Member of Parliament & Chairman of Parliamentary Standing Committee on Ministry of Agriculture, Bangladesh	07.12.2012
6.	Dr. O.P. Gill Vice Chancellor, MPUAT, Udaipur	22.12.2012
7.	Dr. S. A. Patil, former Vice Chancellor of University of Agricultural Sciences, Dharwad and Director IARI, New Delhi	18.1.2013
8.	Sh Ram Chandra Choudhary, Chairman Ajmer Dairy Board, Ajmer	25.01.2013
9.	Sh. Narayan Singh, Chairman Rajasthan Kisan Ayog	29.08.12
10.	Sh. C. B. Gena, Former Vice Chancellor, MGS University, Bikaner	2.11.12
11.	Dr. A.S. Faroda, Former Chairman, ASRB, New Delhi and Former VC, MPUAT Udaipur	17.01.2013
12.	Dr. M.M. Anwer, Former Director, NRCSS	19.01.2013
13.	Sh Hawa Singh Hooda, Advocate General of Haryana Government	15.02.2013
14.	Shri A.M. Tiwari, Managing Director, Gujarat Narmada Valley Fertilizers & Chemicals Ltd.(GNFC)	15.02.2013
15.	Dr. S. M. K. Naqvi, Director, Central Sheep and Wool Research Institute, Avikanagar 304501 (Rajasthan)	15.02.2013

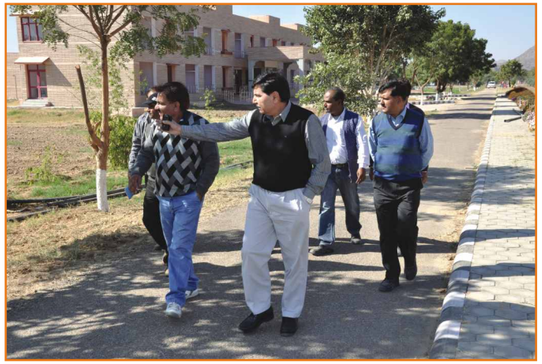
Dr. R. S. Paroda Former DG, ICAR visiting experiments at NRCSS, Farm

Dr. S. A. Patil Chairman QRT visiting experiments at NRCSS Farm

Dr. R. S. Paroda former DG, ICAR and Dr. A. K. Singh, DDG, NRM, planting the tree during inauguration of Scientist Training Hostel

Sh. H. S. Hooda, Advocate General, Haryana Government visiting NRCSS farm

Mr. Shawkat Momen Shahjahan, Member of Parliament & Chairman of Parliamentary Standing Committee on Ministry of Agriculture, Bangladesh visiting NRCSS Farm



Dr. O.P. Gill, Vice Chancellor, MPUA&T, Udaipur visiting NRCSS Farm

15. Empowerment of Women

Training of women on packaging of spices

Post harvest handling of seed spice crops are largely carried out by women farmers. Since all seed spices are directly consumed by human being in the form of cooked or uncooked food, it is very important to maintain cleanliness and best hygiene during post harvest handling of seed spice produce. Value addition for attracting better price is another issue need attention in present perspectives. To address these issues in detail, NRCSS organized one training programme on “Onboard export oriented good packaging practices for whole and blended spices”. The participants were a group of 25 women of a SHG involved in spice grinding, packaging and marketing of seed spices. During the three days training participant women learned about the issues of packaging, processing, on farm practices, post harvest handling, insect–pest management during storage, packaging laws and regulations. Apart from this they packed 5000 pouches of blended spices using scientific methods under hygienic conditions. These pouches were exported successfully.

Participation of women farmers in National Kisan Mela

Special attention was given on participation of women farmers during National Kisan Mela organised by NRCSS on 15th Feb., 2013. More than 400 women participants attended the Mela and Kisan Sangoshti. Dedicated quiz programme was organized for women farmers and they were awarded by giving prizes.

16. Infrastructure Development

16.1 Works under Plan

Scientist's Training Hostel

The construction work of the Scientists Training Hostel at an estimated cost of Rs. 145.96 lakhs has been completed through CPWD. The building was taken over in the month of August, 2012 and formally inaugurated by Dr R. S. Paroda Chairman, Haryana Kissan Aayog & former DG, ICAR on 10 August, 2012. The hostel became functional from 1st January, 2013.

Fully automatic Irrigation system

Facility of fully automatic irrigation system having drip (offline as well as online), micro sprinkler, mega net sprinkler, traditional sprinkler has been established and inaugurated by Dr A. K. Singh DDG, NRM, ICAR. The system is designed to have experiments on water requirement, irrigation scheduling and fertigation in different seed spices. The system can be operated, controlled and monitored online through laptop, computer or mobile.

Conference Hall

The construction work of the Conference hall has been completed at a cost of ` 95.00 lakhs through CPWD. The building is in use for conferences, official functions and meetings.

Works under NHM Projects

Construction work of a Seed Store at an estimated cost of ` 9.96 lakhs has been initiated through CPWD.

Works under Non Plan

1. Construction work of a Farm Store Shed was taken up through CPWD at an estimated cost of `4.98 lakhs.
2. Construction work of a field laboratory was taken up through CPWD at an estimated cost of ` 4.71 lakhs.
3. The conference hall being an integral part of the main laboratory cum administrative building was energized with 3Ph electric supply and provided with AC facilities.
4. The Scientist Training Hostel was furnished with bed room, reception and canteen furniture and provided with AC facilities.
5. Old Seed Store building near threshing floor was renovated at a cost of ` 3.13 lakhs through CPWD.
6. Repair and maintenance work of main building was taken up through CPWD at an estimated cost of ` 4.23 lakhs.
7. Repair and maintenance of residential and old building was taken up through CPWD at an estimated cost of ` 3.52 lakhs.
8. Renovation work of old office building and stores was started at an estimated cost of ` 18.70 lakhs wherein the asbestos roofs would be replaced with RCC roofs so as to make the structures as permanent ones.

17. Personnel

17.1 Promotion

S.No.	Name of Personnel	Post held	Promoted to	W.E.F.
1.	Dr. S. N. Saxena	Senior Scientist (Plant Physiology)	Principal Scientist	8 May 2011
2.	Dr. R.K. Kakani	Senior Scientist (Plant Breeding)	Principal Scientist	15 June 2011
3.	Dr. Y.K. Sharma	Senior Scientist (Plant Pathology)	Principal Scientist	15 Nov 2011

17.2 Transfer/Resignation

S.No.	Name of Personnel	Post held	Transferred to	Date
1.	Dr. Balraj Singh	Pri. Scientist, IARI, New Delhi	Director, NRCSS	1 Sep 2012
2.	Sh. M.K.M.Nair	AO, NRCSS	DOR, Hyderabad	5 May 2012
3.	Sh. Ravindra Singh	AO, IIVR, Varanasi	AO, NRCSS	5 May 2012
4.	Sh. Asif Beg	Assistant, NRCSS	Resignation	19 Dec 2012

17.3 Scientific Staff

S.No.	Name	Designation
1.	Dr. Balraj Singh	Principal Scientist and Director
2.	Dr. Gopal Lal	Principal Scientist (Horticulture)
3.	Dr. S.N. Saxena	Principal Scientist (Plant Physiology)
4.	Dr. R.K. Kakani	Principal Scientist (Plant Breeding)
5.	Dr. Y.K. Sharma	Principal Scientist (Plant Pathology)
6.	Dr. R.S. Mehta	Senior Scientist (Agronomy)
7.	Dr. Ravindra Singh	Senior Scientist (Agronomy)
8.	Dr. O.P. Aishwath	Senior Scientist (Soil Science)
9.	Dr. Krishna Kant	Senior Scientist (Entomology)
10.	Dr. S.S. Meena	Senior Scientist (Horticulture)
11.	Dr. J. K. Ranjan	Senior Scientist (Horticulture)
12.	Dr. S. S. Rathore	Senior Scientist (Biochemistry)
13.	Dr. B. K. Mishra	Senior Scientist (Microbiology)
14.	Dr. R.S. Meena	Scientist (Plant Breeding)
15.	Dr. R. K. Solanki	Scientist (Plant Breeding)
16.	Dr. Sharda Choudhary	Scientist (Biotechnology)
17.	Dr. R. D. Meena	Scientist (Plant Pathology)
18.	Sh. Mukesh Kumar Vishal	Scientist (Ag. Statistics)

17.4 Technical Staff

S.No.	Name	Designation
1.	Sh. S.P. Maheria	Technical Officer (T 7-8)
2.	Sh. M.A. Khan	Technical Officer (T 7-8)
3.	Sh. S.R. Meena	Technical Officer (T 5)
4.	Sh. G.K. Tripathi	Technical Assistant (T 3)
5.	Sh. Pramod Agarwal	Technical Assistant (T 1)
6.	Sh. Sri Ram Balai	Technical Assistant (T 1)
7.	Sh. Ajit Singh	Technical Assistant (T 1)

17.5 Administrative, Audit & Accounts and Supporting Staff

S.No.	Name	Designation
1.	Sh. Ravindra Singh	Administrative Officer
2.	Sh L.K Sharma	Asstt. Administrative Officer
3.	Sh. Bhim Singh	Assistant
4.	Sh. Sanjeev Sharma	Assistant
5.	Sh. M. M. Vanvi	Assistant
6.	Sh. R. K. Kanwaria	Sr. Clerk
7.	Smt. Sarla Devi	SSG-I
8.	Sh. Pukhraj Paroda	SSG-I

17.6 Personnel

Grade	Sanctioned	Filled	Vacant
Scientific	20	17	3
Technical	8	7	1
Administration	11	5	6
Supporting	2	2	0
Total	**41**	**31**	**10**

18. Other Informations

Dr Balraj Singh Joined Director NRCSS, Ajmer

Dr. Balraj Singh, joined as Director, NRCSS on 1st September, 2012. Prior to this Dr. Singh was working as Principal Scientist and Incharge of the Centre for Protected Cultivation Technology at IARI, New Delhi. Before joining ICAR as Senior Scientist in November 1998, Dr. Singh served SKRAU Bikaner for more than 9 years as Assistant Professor (Horticulture). His major research areas are vegetable seed production technology and production technology of vegetables under protected conditions. He has standardized zero energy naturally ventilated green house technology for vegetable cultivation suited to Indian conditions, plastic low tunnel and walk in tunnel technology for off-season vegetable cultivation, virus free plug tray nursery raising technology for vegetables, insect proof net house technology for safe vegetable cultivation, quality hybrid seed production technology of cucurbits, production technology with fertigation by high and low pressure drip in tomato, cherry, coloured capsicum, and seed crops of carrot, onion, and coriander etc. Dr. Balraj Singh is the fellow of Indian Society of Seed Technology, fellowship of the Academy of Science, Engineering and Technology and fellow of the Horticultural Society of India for outstanding contribution in the promotion of Protected Cultivation of Vegetable and Horticultural crops. Dr. Balraj Singh is the elected Senior Vice-President of the Indian Society of Seed Technology and the Secretary of the Indian Society for Protected Cultivation. He has International exposure as invited speaker, chairman of various sessions in different international conferences, seminars and symposia and encompassed countries like Australia, Singapore, Malaysia, Japan, China and Israel. He is a member and chairman of TAC of the Central Institute of Horticulture Dimapur (Nagaland) and Chairman of the Technical Advisory Committee for establishment of a Centre of Excellence on Hi-tech Horticulture by the Department of Horticulture, Government of Odisha.

fgUnh i[kokMk

fnukd 14 l 30 fl rEcj 2012 rd fgUnh i[kokMk euk;k x;k A bl Øe e fnukd 14-09-2012 dk fgUnh fnol eukdj fgUnh i[kokM dk vkjEHk fd;k x;kA bl volj ij lLFkk d fun'kd Mk- cyjkt flg egkn; }kjk fgUnh Hkk"kk d egRo dk /;ku e j[kdj dk;ky; d lHkh vko';d dk; ,o i=&i=kofy;k dk fgUnh e idk'ku dju ij /;ku vkd"V fd;k x;kA blh Øe e fnukd 21 fl rEcj dk dUn d lHkh oKkfudk ,o lgk;d depkfj;k d fy, fofHkUu ifr;kfxrk, vk;kftr dh x;h ftue okn&fookn] rkRdkfyd Hkk"k.k] dk;ky; fVli.kh y[ku ,o vU; ifr;kfxrk, 'kkfey FkhA Mk- ct'k dekj feJ] iHkkjh jkt Hkk"kk u fgUnh Hkk"kk dh egRrk ij tkj ndj Hkfo"; e fgUnh e dk; dju d fy; lHkh dk ikRlkfgr fd;kA dk;Øe d lekiu ij fo trkvk dk ijLdkj inku fd; x;A

New variety of Fenugreek identified

A new variety of fenugreek, Ajmer Fenugreek-3 (AFg-3) has been identified for national release in XXIII meeting of AICRP on spices held at IISR, Calicut. The variety is identified for higher yield as well as better quality especially for diosgenin and 4-hydroxy-iso-leucine content. AFg-3 gave 11.13 % higher seed yield than Hisar Sonali (national check) in coordinated trials testing at 12 locations across the

country over three years with 1288 kg/ha.This variety is most stable and desirable for yield as per Eberhart and Russel Model. For most of the ancillary traits this variety is at par with national check. It is moderately resistant to powdery mildew and root rot diseases. Its seed contains 1.79 % diosgenin which is higher than national check. Free amino acid 4-hydroxyisolucine content in the seed of AFg-3 is 0.97 % which is higher than other available varieties.

Bio control laboratory established

Bio control laboratory has been established under NHM. In the laboratory modern facilities for mass production of biocontrol agents like soil antagonist, entomopathogens and predators have been developed and utilized in various programmes at centre as well as in other projects.

Foundation day celebrated

NRCSS celebrated 13th foundation day on 19th January, 2013. Dr A.S. Faroda, Former Chairman, ASRB, New Delhi and Former VC, MPUAT, Udaipur Presided over the function. Prof. S.A. Patil, Chairman, Karnataka Krishi Mission & Former Director, IARI, New Delhi, & Former Vice-Chancellor, UAS Dharwad delivered the 3rd Foundation day lecture on "Employment Opportunities and Role of Youths in Indian Agriculture". The function was attended by the staff of NRCSS, ATC Ajmer, KVK Ajmer and State Agriculture Department.

Dr. Gopal Lal visited Texas A&M University (USA)

Dr. Gopal Lal, Principal Scientist (Horticulture) visited Texas A&M University (USA) on short duration study visit "To Acquaint with State of art Techniques in Post Harvest Management of Horticultural Crops" during 4 to 17 June, 2012.

Pertinent points emerged from the visit were management of pre-harvest factors to have quality produce, precision farming of vegetables and fruits, harvesting and post harvest handling of fruits and vegetables, processing and product manufacturing for value addition and utilization of processing waste.

Dr. S. N. Saxena attended IFT Annual Meeting & Food Expo 2012

Dr. S. N. Saxena, Principal Scientist (Plant Physiology) attended IFT Annual Meeting & Food Expo 2012 organized by the Institute of Food Technologists at Las Vegas Convention Centre, Las Vegas, Nevada, USA during June 25 to 28, 2012. This visit was sanctioned in the NAIP IV project titled "Studies on Cryogenic Grinding for Retention of Flavour and Medicinal Properties of Some Important Indian Spices".

More than 18000 food industry professionals were gathered in the meeting. The scientific programme boasted more than 100 education sessions and 12000 posters presentations. The key focus area programme tracks were Food safety and defense, Food health and nutrition, Food processing and packaging, Product development & Ingredient innovations, Sustainability, Public policy, Food laws and regulations and Education & Professional development. The core science programme tracks were Food Chemistry, Food Microbiology, Food Engineering and Sensory Science. In IFT Food Expo more than 900 companies from around the World and more than 1,900 booths were there as exhibitors.

Spice Board of India, Cochin along with other Indian exporters mainly deals in spices exhibited their products and technology in Food Expo.

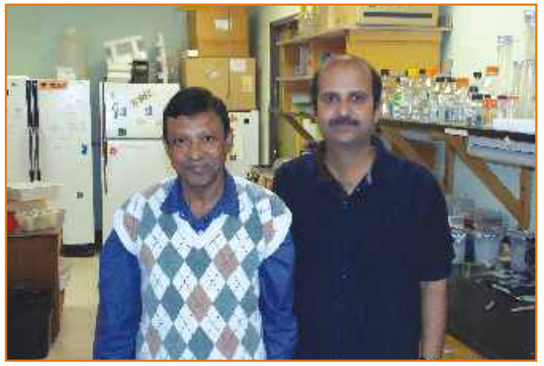
International Training under NAIP

Dr. R.S. Mehta

Dr. R.S. Mehta, Senior Scientist (Agronomy) undertaken three months training on Sensor Based Applications Including Bio Indicators under the guidance Dr. Kenneth A. Sudduth, Agriculture Engineer, USDA-ARS and Adjunct Professor, University of Missouri, Columbia from September 04 to December, 02, 2012. He got training on use of different crop canopy sensors comprising Crop Circle -210, Crop Circle 430, Rapid Scan-45, Green Seeker Data Collection & Mapping Unit and Hand Held Green Seeker Dr. Mehta also associated in study on "In season nitrogen management in Tall Fescu (*Festuca arundinacea*) with use of different crop sensors" for understanding, learning various aspects of in season nitrogen management in field crops.

Dr. J.K. Ranjan

Dr. J.K. Ranjan, Sr. Scientist (Horticulture) successfully completed three months training under the guidance of Dr. C. Kole, Director of Research, Institute of Nutraceutical Research, in the area of "Marker Assisted Selection in Horticulture" at Department of Genetics and Biochemistry of Clemson University, USA from August 15 to November 12, 2012. During the training programme he has developed several Amplified Fragment Length Polymorphism (AFLP) markers for enrichment of molecular map of bitter melon required for mapping genes and QTLs underlying important fruit traits and content of the major anti-diabetic and anti-cancerous Phyto-medicines. He also visited other laboratories in the Clemson University to learn



advance concepts, tools and strategies of plant genomics, biotechnology and molecular breeding.

Visit of QRT AICRP on Spices

QRT members of IISR and AICRP on Spices, Calicut visited the NRCSS on 9th October, 2012. Dr Balraj Singh welcomed the chairman and all the QRT members and presented ongoing research activities including AICRP projects on seed spices at NRCSS. The QRT members appreciated the ongoing projects and research work going on at NRC on Seed Spices and suggested to submit the important lines of different seed spices in coordinated trials for multi-location testing before release as varieties.

jktLFkku fdlku vk;kx dk lHkkx Lrjh; d"kd lokn dk;Øe

Pkk/kjh Jh ukjk;.k flg th] v/;{k] jktLFkku fdlku vk;kx d lkfu/; e fnukd 29 vxLr 2012 dk jktLFkku lHkkx Lrjh; d"kd lokn dk;de dk vk;ktu] n;kUkUn dkyt lHkkxkj e fd;k x;kA bl volj ij fdlku vk;kx d ekuuh; lnL; Jh ch- ,e- nhf{kr] ik- ,- d- xgykr] Mk- vk-ih- ikjhd] Jh ,u- ,l- jkBkM] Mk xkiky yky] Jhefr lfp=k vk; ,o Jh lUnje mifLFkr FkA bl dk;de e vtej] Vkd] nkl rFkk t;ijftyk d yxHkx 200 fdlkuk u Hkkx fy;k vkj viuh leL;kvk vkj l>kok dk jktLFkku fdlku vk;kx d le{k iLrr fd;kA jktLFkku fdlku vk;kx d v/;{k Pkk/kjh Jh ukjk;.k flg th] ,o lnL;k u fdlkuk dh leL;kvk dk nj dju d fy, viuh ifrc)rk idV dh rFkk lHkh fdlkuk l vkxg fd;k fd o viu fopkj i=] QDl o VyhQku d }kjk Hkh Hkt ldrgA

Parliamentary Standing Committee Delegation of Bangladesh Visited NRCSS, Ajmer

On Dec 7, 2012 a delegation from Bangladesh headed by Honourable Mr. Shawkat Momen Shahjahan, Member of Parliament & Chairman of Parliamentary Standing Committee on Ministry of Agriculture with the scientists from Bangladesh and Dr. A. Sarkar, Nodal Officer, ICARDA, New Delhi visited NRCSS, Ajmer. On this occasion Dr. Balraj Singh, Director, NRCSS welcomed the delegates and briefed them about NRCSS research activities and programmes. Delegates highly appreciated the research done on seed spices and also enquired about the recommended cultivation practices followed in India. In Bangladesh around 2% land is under spice and seed spices cultivation. To fulfill their domestic need they import considerable amount from India. There was interactive session held between delegates and scientists of NRCSS on the scope and feasibility of seed spices cultivation in Bangladesh. Mr. Shahjahan was interested to expand seed spice area in Bangladesh with the help of NRCSS, India. The delegation also visited the experimental farm of NRCSS to see various experiments going on in different seed spices.

o"kkfud ,oa rduhdh 'kCnkoyh vk;kx dh cBd

Hkkjr ljdkj d ekuo lalk/ku fodkl e=ky; d v/khu oKkfud ,o rduhdh 'kCnkoyh vk;kx }kjk ,uvkjlh,l,l e fnukd 18&22 Qjojh] 2013 rd cBd dk vk;ktu fd;k x;k ftle ogn ikfjHkkf"kd 'kCn lxg] df"k foKku d vn;ruhdj.k dk dk; fd;k x;kA

19. Technical Programme

S. No.	Project	Name of Sub- project
	Crop Improvement	
1.	Collection, evaluation and documentation of plant genetic resources of seed spices Project Leader : Dr. R. K. Solanki	CI-1. Management of plant genetic resources of seed spices New Sub Project: Cytological and biochemical characterization of cumin
2.	Breeding for improvement in major seed spices Project Leader :Dr. R. K. Kakani and Dr. R.S. Meena	CI-2. Breeding for high yield, quality & resistance to biotic & a biotic stress in Fenugreek CI-3. Breeding for high yield and quality in coriander CI-4. Breeding for high yield, quality & resistance to biotic & abiotic stresses in Fennel CI-5 Breeding for high yield, quality & resistance to biotic & abiotic stresses in cumin New Sub Project: Enhancing genetic variability in cumin
3.	Breeding for improvement in minor seed spices Project Leader : Dr. S.S. Meena	CI-6 B reeding for high yield, quality & resistance to biotic & abiotic stress in Caraway CI-7 Breeding for high yield, quality & resistance to biotic & abiotic stress in celery CI-8 Breeding for high yield and quality in Dill (*Anethum graveolens* L & *Anethum sowa* Kurz.) CI-9 Breeding for high yield &improved quality in Ajwain for *Rabi* and *Kharif* season CI-10 Breeding for high yielding and improved quality in Nigella CI-15 Genetic enhancement of Anise for yield and yield contributing traits
4.	Deciphering molecular diversity and molecular characterization in seed spices Project Leader : Dr. Sharda Choudhary	CI-12 Genetic diversity analysis through biotechnological tools in fenugreek CI-13 Molecular characterization of cumin CI-18 Genomic study of seed spices (Fennel, coriander, ajowain, nigella)
5.	Basic and applied studies on artificial hybridization in major seed spices Project Leader : Dr. J.K. Ranjan	CI-16 Standardization of Technologies for crossing in coriander (*Coriandrum sativum* L.)
	Crop Production	
6.	Post Harvest management and value addition in Seed Spices Project Leader : Dr. G. Lal	CPd-9 Development of integrated system for processing with MAP of seed spices (cumin, fennel)
7.	Precision resource management in seed spices Project Leader : Dr. Ravindra Singh	New Sub Project: Fertigation scheduling for efficient nutrient and water use in major and minor seed spices CPd-15 Scaling up water productivity in seed spices cultivation (cumin, Nigella)
8.	Cropping system and weed management in seed spices Project Leader : Dr. R.S. Mehta	CPd-16 Effect of land configuration and water management techniques on yield of seed spices in maize (babycorn) based cropping system CPd-17 Identification of critical stage for weed management in seed spices CPd-18 Standardization of sustainable and profitable cropping system with fruit crops CPd-23 Standardization of NPK levels for coriander and cumin under protected environment in the scenario of climate change

S. No.	Project	Name of Sub- project
9.	Assessment of edaphic stresses and nutrient management for sustainable seed spices production Project Leader : Dr. O. P. Aishwath	CPd-8 Seed spices crop residue recycling through vermi-composting for nutritional and carbon budgeting
10.	Microbiological approaches in integrated nutrient management in seed spices Project Leader : Dr. B.K. Mishra	CPd-19 Screening of plant growth promoting rhizobacteria for coriander (*Coriandrum sativum* L.) CPd-20 Isolation and evaluation of phosphate solubilising microorganisms for fennel (*Foeniculum vulgare* L.)
	Crop Protection	
11.	Survey & surveillance of existing and emerging diseases and insect pests in seed spices Project Leader : Dr. R D Meena	New Sub Project: Survey & surveillance of existing and emerging diseases and insect pests in seed spices
12.	Management of insect pests in seed spices Project Leader : Dr. Krishna Kant	CPt-8 Management of Seed Insect -Pest of seed spices through Modified Atmospheric packaging and other non chemical methods CPt-9 Management of fennel seed wasp
13.	Management of diseases in seed spices Project Leader : Dr. Y.K. Sharma	CPt-10 Evaluation of *Trichoderma* species for the management of wilt (*Fusarium oxysporum* f.sp. cumini) disease of cumin CPt-12 Management of wilt disease in cumin through soil solarisation
	Basic Science	
14.	Physiological approaches for enhancing yield and quality in seed spices under abiotic stresses Project Leader : Dr. S. N. Saxena	New Sub Project: Physiological approaches for enhancing yield and quality in seed spices under abiotic stresses
15.	Biochemical basis of defence mechanism and quality traits in seed spices Project Leader : Dr. S. S. Rathore	BS-6 Biochemical basis of defense mechanism in cumin *(Cumunum cyminum L.)* BS-7 Quality profiling of coriander and fenugreek germplasm
	Social Science	
16.	Seed spices knowledge management and technology transfer Project Leader : Shri. M.K. Vishal	CPd-21 Design and development of database for seed spices. CPd-22 Development of seed spices atlas of India using GIS approach. SS-1. Awareness and adaptation of seed spices production technology

ANNEXURE 1

Spice Wise Area & Production (Area in Hec, Production in Tonnes)

Spices	2007 – 08		2008 – 09		2009 – 10		2010 – 11(P)		2011-12 (Adv.Est.)	
	Area	Prodn.	Area	Prodn.	Area	Prodn.	Area	Prodn.	Area	Prodn.
Coriander	457605	286414	537327	471515	530789	501485	474250	372366	557870	532947
Cumin	477936	264860	527132	283000	517133	303943	625087	403744	593980	394328
Celery	3158	4239	4117	5329	4312	5248	3776	4609	4174	5264
Fennel	89894	136984	74149	114277	53497	83576	81890	125710	99554	142949
Fenugreek	55520	70155	74512	97533	71985	88979	94760	127850	93605	115929
Ajwan	35635	20641	26148	18301	20628	8950	27257	19327	35376	26778
Dill seed	18347	20392	13139	13363	8537	10447	26698	33090	21900	23632
Grand total including others	1138095	803685	1256524	1003318	1206881	1002628	1333718	1086696	1406459	1241827
G. Total (M.T.)		0.803685		1.003318		1.002628		1.086696		1.241827

Source: Spice Board, India

ANNEXURE 2

Seed Spices Statistics at a Glance at National Level (2010-11)

Crop	Total area (Hac)	Area share among Seed Spices (%)	Area Share among Spices (%)	Total Production (Tonnes)	Production Share among Seed Spices (%)	Production Share among Spices (%)	Productivity (Qt/Ha)
Cumin	50,78,50	41.6	17.36	3,14,220	29.69	5.89	6.18
Coriander	53,08,60	43.52	18.15	4,82,230	45.57	9.04	9.08
Fennel	61,680	5.05	2.10	1,05,320	9.95	1.97	17.07
Fenugreek	81,220	6.65	2.77	1,18,360	11.18	2.22	14.57
Ajwain	25,850	2.12	0.88	22,180	2.09	0.41	8.58
Dill	8537	0.70	0.29	10,447	0.98	0.19	12.23
Celery	4312	0.35	0.14	5248	0.49	0.09	12.17
Total	12,20,309	-	41.72	10,58,005	-	19.84	11.41

Source: Spice Board of India data 2010-11 (Total Spice area: 2924299 Ha; Total Spice Production: 5330071 Tonnes)

ANNEXURE 3

Seed Spices Export at a Glance at National Level (2010-11)

Crop	Export Qty (Tonnes)	Export Qty % Share	Export Value (In Lakhs)	Export Value Share (%) (In Raw produce)	Export Value Share (%) (In Total including finished Produce)
Cumin	32,500	8.48	39,597.75	9.84	5.78
Coriander	40,500	10.57	16,663.25	4.14	2.43
Fennel	7250	1.89	6588.25	1.63	0.96
Fenugreek	18,500	4.83	6548.1	1.62	0.95
Ajwain	-	-	-	-	-
Dill	-	-	-	-	-
Celery	-	-	-	-	-
Total	98,750	9.68	69,397.35	17.25	10.14

Export Value Raw produce: 402278.5 Lakhs; Export Value of Spices including finished or value added produce: 684070.5 Lakhs)

National Research Centre on Seed Spices

Tabiji, Ajmer-305 206 (Rajasthan) INDIA

Ph. : 0145-2684401, 2684402• Fax : 0145-2684417

Website : www.nrcss.org.in