Advance Production Technology of

Coriander

(*Coriandrum sativum* L.)

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PREFACE

Among the seed spices, coriander occupies the top place in terms of area, production and export. The major producing countries other than India are Morocco, Russia, Bulgaria, Mexico, Argentina, China, Romania, Japan and Italy. In India, coriander is largely cultivated in Rajasthan, Madhya Pradesh, Andhra Pradesh, Tamil Nadu, Orissa, Uttar Pradesh, and Uttaranchal states. Rajasthan is major coriander growing state with its share of about 60% in the total area and production of the country. Many production technologies have been generated at National Research Centre on Seed Spices and under All India Co-ordinated Research Project on Spices. Here in this publication efforts have been made to present specific recommendations for different area, states for increasing the production and productivity of coriander. Besides this, the publication deals with IPM strategies for coriander which is a burning need of the era for sustainable agriculture. We are assured that this publication shall prove highly useful to various stake holders such as field functionaries, growers, exporters, students and others having interest in cultivation of coriander scientifically.

We hope that this technical bulletin will provide relevant information. Suggestions if any for its improvement are welcome for future publications.

Ajmer Authors

February , 2010

Introduction

Coriander (*Coriandrum sativum* L) is an important seed spice crop of family Apiaceae. It is an upright and branched annual plant that grows to a height of 80 cm. The leaves of the plant in our rural and urban areas are used to make chutney. The whole plant is aromatic. The flowers are small, white and pink in colour produced in umbels. Fully mature seeds on getting dried turn light brown in colour. The green leaves are also used in salads, soups and prickles. Most of housewives give a generous sprinkling of the green leaves on cooked dishes of meat, pulses and vegetables before they are served. The seeds are also used in thickening and flavouring soups, curries and liquors. The stems of the plant are used in cooking in Vietnam. The roots have little use in our cooking, but the Thais greatly relish them in their cuisines. Thus no part of the plant goes waste. It is known as coriander in English and Dhania in Urdu. In the US, it is known as Cilantro, a word derived from the Spanish language. It is believed to be a native to southern western Asia to North Africa. It grew wild in the north-eastern and the southern part of Europe.

Climate and soil

Coriander is a tropical crop and can be grown throughout the year (except very hot season i.e. March-May) for leaf purpose. For seed purpose a dry and cold weather, free from frost especially during flowering and fruit setting stage is required. Germination of coriander is severely reduced attemperature above 30°C and below 10°C. Heavy rains are harmful for the crop and continuous cloudy weather invites diseases and aphids. For green, it can be grown throughout the year provided moisture is made available. However, it does not grow well in spring summer season for greens, because it switches over within short time from vegetative growth to reproductive phase as soon as temperature raises beyond 20°C

The coriander can be grown in any type of soil suitable for cultivation. It is cultivated both as irrigated and un-irrigated crop. As an irrigated crop, it can be cultivated in almost all type of soils having sufficient organic matter but dry land crop may be taken only on heavy soils having good water retention capacity. pH of soil should be near 7.0 for better growth and quality produce of coriander. Saline, alkaline and sandy soils are not suitable for its cultivation.

Field preparation

Coriander is mainly grown as dryland crop on heavy soils. For dryland coriander cultivation, field must be ploughed after rain for conservation of soil moisture. Field must be kept either fallow or short duration crop like green gram or black gram may be grown and should be harvested as early as possible at physiological maturity stage to take dryland crop of coriander. In rainy season, if

field is kept fallow or just after harvesting of previous *Kharif* crop, first ploughing should be done with soil turning plough. It should be followed by 2-3 ploughing with cultivator or harrow or *desi* plough to obtain fine soil tilth. To avoid loss of soil moisture and to break the clods, the field should be planked immediately after ploughing. For irrigated coriander if soil moisture is not sufficient, preparatory tillage should be carried out after giving pre-sowing irrigation. Application of pre-sowing irrigation will also help to germinate the weed seeds which will be uprooted, killed and turn in the soil at the time of field preparation. This practice is termed as stale seed bed preparation which will help to minimize the weed competition, particularly during early crop growth period. Less number of ploughing are required in light soils whereas more number of ploughings are required in heavy soils. At the time of sowing, soil must be friable to obtain better seed bed for better seedling emergence and their further establishment.

State-wise recommendations

(A) Andhra Pradesh Varieties

Swathi: It is developed by mass selection from CS 6 of Nadia region, A.P. at Regional Research Centre, Lam (APAU), Guntur in 1989. It is an early maturing dual purpose variety. It is suitable for cultivation under dry land conditions of A.P. It possesses field tolerance to white fly, mites and aphids. Plants are of medium in height and seeds are oval, bold and of straw colour. It matures in about 100 days with 1000-1100 kg seed yield/ha.

Sindhu: It is developed at Regional Research Center, Lam (APAU), Guntur. It is suitable for inter cropping and dryland farming system of Andhra Pradesh state. The plants are dwarf type and bear oval shape and medium bold seeds with straw colour. It is a medium duration variety and mature in about 100-105 days with an average seed yield of 1000 kg/ha. It is tolerant to wilt, powdery mildew and aphids.

Lam Selection CS 2: It was developed at Regional Research Center, Lam (APAU), Guntur and is suitable for A.P. Its plants are bunchy with more branches and medium in height. Seeds are of good quality, which contains about 0.40 per cent essential oil. It matures in about 110 days and gives about 1030 kg seed yield/ha. It is relatively tolerant to harmful diseases and insect pests.

Sadhna: A semi erect variety developed at APAU, Regional Research Centre, Lam, Guntur. It is an early maturing and dual purpose variety. It is suitable for cultivation under rainfed conditions

ofAP and also possess field tolerance to white fly and mites. It matures in 100 days with an average yield of 1030 kg/ha of bold, oval, straw coloured grains.

Sowing time: The seeds are sown between 15thof October to 15th of November.

Spacing: Row to row spacing 30cm and plant to plant spacing in a row should be kept 10-15cm.

Manures and Fertilizers: 10-15 tonnes of FYM + 30:40: 20 kg NPK/ha in single dose in last ploughing. Apply N in two equal splits at sowing and 60DAS. At the time of field preparation full dose of P & K. should be applied with first split ofN in the soil.

(B) Bihar

RajendraSwathi: It was developed in the year 1988 for Bihar state through mass selection from R.D. 44 at Regional Research Center, Rajendra Agricultural University, Dholi, Bihar. Plants are medium in height and suitable for mixed/inter cropping. Its seeds are round, fine, small, aromatic and contains high essential oil. It is resistant to stem gall and moderately resistant to wilt, aphids and weevil. It matures in 100 days with seed yield of 990-1170 kg/ha.

Rajendra Sonia: It is a medium-tall, high yielding variety, developed at Rajendra Agricultural University, Regional Research Centre Dholi in Bihar. This variety gives an average yield of 1200kg/ha. Crop matures in about 110 days and is resistant to stem gall, moderately resistant to wilt, aphid, weevil and tolerant to fruit fly.

Sowing time: First week of October

Spacing: 30 cm x 20 cm

Manures and Fertilizers: 60:40:20 kg NPK/ ha under irrigated conditions. Apply N in two equal splits at sowing and 60DAS. At the time of field preparation full dose of. P & K should be applied with first split ofN in the soil.

(C) Haryana

Hisar Sugandh: This variety is developed at CCS Haryana Agricultural University, Hisar. It is a high yielding dual purpose variety of coriander, suitable for Haryana. It has wider adaptability to different soil conditions and can be grown as rain fed as well as irrigated crop. On an average, it gives 1400 kg/ha seed yield.

Hisar Anand: It is a dual purpose high yielding variety developed at CCS, Haryana Agricultural University, Hisar. This variety has wider adaptability to different soil conditions. The average yield is 1400kg/ha seeds.

Hisar Surabhi: A high yielding variety having medium sized seed developed at CCSHAU, Hisar. It is frost tolerant, less susceptible to aphids and grains having good oil content (0.425%). The plants are bushy, erect, 15cm tall, duration is medium (130-140 days) and yields 1800-2000 kg/ha.

Sowing time: Second week ofNovember

Spacing: 50 cm x 20 cm

Manures and Fertilizers: 60kg N, & 37.5 kg P/ha. Nitrogen should be applied in two split doses as basal and at flower initiation stage and P& K as single basal dose before last ploughing.

(D) Gujarat

Gujarat Coriander -1 (GCr-1)

This variety was developed by selection method from local variety at Spices Research Centre (Jagudan under AICRP on Spices in Sardarkrushinagar Dantiwada Agricultural University, Gujarat. It was identified in 1974 and had been recommended for Gujarat state. The plants are erect and medium in height having more branches. Seeds are round and having green-yellow colour. It matures in 112 days and It gives seed yield 1100 kg /ha. It is also suitable for sowing as early crop under irrigated condition.

Gujarat Coriander- 2 (GCr-2)

This variety was developed by All India Coordinated Research Project on Spices at Spices Research Center Jagudan in Sardarkrushinagar Dantiwada Agricultural University, Gujarat. It was improved through breeding technique and developed from Co- 2 germplasm. It was developed for whole Gujarat and Rajasthan and is suitable for early sowing under dry-land condition. . The plants are semi spreading in growth habit and bear more secondary branches with dense and dark green foliage having large sized umbel and medium bold seeds. It matures in 110-115 days and gives an average seed yield 1400- 1600 kg/ha. It is mostly suitable for seed purpose but can also be grown as leafy purpose. It is moderately tolerant to wilt and powdery mildew.

Gujarat Coriander-3 (GCr-3)

This variety was developed by selection method from local variety at Spices Research Centre (Jagudan under AICRP on Spices in Sardarkrushinagar Dantiwada Agricultural University,

Gujarat. The plants are erect and medium in height having more branches. Seeds are oval and having seed colour light brown. It matures in 110-120days and It gives seed yield 1100 1200 kg /ha. It is also suitable for sowing as early crop under irrigated condition.

Manures and Fertilizers: 20 tonnes of FYM + 60:60:30 kg NPK/ha. Nitrogen should be applied in two split doses as basal and at flower initiation stage and P& K as single basal dose before last ploughing.

(E) Rajasthan

Ajmer Coriander-1 (ACr-1)

This variety was developed through mass selection method and released at state level in 2015 by SVRC. It is a variety of late maturity group developed at NRCSS, Ajmer is suitable for leaves and seeds production, and grows well under irrigated. It contains essential oil 0.6 per cent and gives an average yield 1250 kg/ha. The plants are tall erect, seeds are medium in size, round in shape and suitable for export purpose. The plants are resistant to stem gall and having tolerance to powdery mildew. This variety is also suitable for growing as greens during off-season under shade net.

Ajmer Coriander-2 (ACr-2)

This variety was developed through recurrent selection method and identified for national released in 2017. It is a variety developed at NRCSS, Ajmer is suitable for leaves and seeds production, and grows well under irrigated essential oil content up to 0.5 per cent and average yield 1290 kg/ha. The plants are semi erect, seeds are medium in size, seed shape is oval and suitable for export purpose. The plants are resistant to stem gall and have tolerance to powdery mildew. This variety is suitable for growing as greens during off-season also under shade net.

Ajmer Coriander-3 (ACr-3)

This variety was developed through recurrent selection method and identified for national released in 2018. It is a variety developed at NRCSS, Ajmer is suitable for seeds production, and grows well under irrigated essential oil content up to 0.55 per cent and average yield 1689 kg/ha. The plants are semi erect, seeds are medium in size, seed shape is oval and suitable for export purpose. The plants are moderately resistant to powdery mildew.

Ajmer Green Coriander-1 (AGCr-1):

This variety was developed through recurrent selection method and released proposal in 2018 at state level. It is developed at NRCSS, Ajmer is suitable for only leaves purpose well grown in

shade net in summer (off season), and essential oil content up to 0.05 per cent and average yield 74.3 q/ha. The plants are tall erect, seeds are medium in size, oval in shape and suitable for export purpose. The plants are resistant to stem gall and have tolerance to powdery mildew.

Rajasthan Coriander-41 (RCr-41)

This variety was developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan) during 1988. It is also found suitable for Gujarat and Haryana. It is suitable for both seeds as well as leafy purpose. It matures in 130-140 days and gives 1100-1400 kg/ha seed yield. Its potential yield is 2700 kg seed yield/ha. It was developed through re-selection of UD-41 and is also known as UD-41 and "Karan". It is best suitable for irrigated conditions but can also be taken as dry land crop in heavy soil type region. Its plants are erect, good in height having purple pinch colour on base of the stem. Seeds are small round in shape having test weight (1000 seeds) of 7-9g and contain 0.25 per cent essential oil, which is about 2-5 per cent higher than local cultivars. It is highly resistant to stem gall and wilt but moderately tolerant to powdery mildew.

Rajasthan Coriander-20 (RCr-20)

The variety was developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan) during 1996, under All India Coordinated Research Project on Spices. It was tested under the name of UD- 20 and also known by this name. It is suitable for dry land cultivation or with limited moisture. Its plant is bushy and spreading with medium height and produces large-size oval seeds. It is moderately tolerant to powdery mildew, wilt and stem gall diseases.

Rajasthan Coriander-435 (RCr-435)

It was developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan) in the year 1995 for Rajasthan state. It is an erect, bushy and medium maturing type, also having medium size of seeds with test weight of 10.4g. It is well adapted to irrigate conditions under high soil fertility. It matures in about 135 days and gives 1000-1400 kg seed yield/ha. The variety is moderately resistant to root knot nematodes and powdery mildew disease.

Rajasthan Coriander-436 (RCr-436)

This variety was also developed in the year 1995 by Sri Karan Narendra Agriculture University, Jobner (Rajasthan). It is suitable for cultivation in heavy soils of Rajasthan as dry land crop. Its plants are semi dwarf with early and quick growth habit and bears bold seeds having 13-14 g of test weight. It is an early maturing type and matures in 90-110 days and gives an average seeds

yield of 1100 kg/ha under limited moisture conditions and gives potential yield 1400-1600 kg/ha under favourable climatic condition.

Rajasthan Coriander-684 (RCr 684)

It was developed in the year 1997 at Sri Karan Narendra Agriculture University, Jobner (Rajasthan). It is suitable for irrigated cropping system of Rajasthan. It is a medium maturity variety (130 days) and gives an average seed yield of 1000 kg/ha. Seeds are bold and having 14.14g of test weight. It is resistant to stem gall disease.

Rajasthan Coriander-446 (RCr- 446)

It is a variety developed at Sri Karan Narendra Agriculture University, Jobner (Rajasthan).It is medium in maturity and bears bold seeds. This variety is suitable for irrigated condition. It matures 130-10 days and gives an average yield 1200kg/ha.. It is moderate resistance to stem gall and wilt disease.

(F) UttarPradesh

Pant Haritma: It was developed at GB Pant University of Agriculture and Technology, Pant Nagar (Uttaranchal). It is a high yielding dual purpose cultivar of coriander bearing fragrant leaves. It is tolerant to stem gall disease. It is a late maturing type and medium in plant growth habit. Its yield potential is as high as 1500 kg seed/ha.

Sowing time: Middle of October to first week ofNovember.

Spacing: 30 x 10cm

Fertilizer: 60:30:30 NPK /ha. Full dose of P & K and 20 kg nitrogen should be applied at the time of sowing and the rest N in two equal splits at 30-35 DAS and second at flowering stage.

(G) Tamil Nadu

Co-1: Coimbatore-1 variety of coriander was developed through selection at Tamil Nadu Agricultural University, Coimbatore in 1981. It is suitable for both leaf and seed production. Its plants are small structured with globular and bear small dusty brown seeds. This variety requires less water and is thus suitable for dryland areas of Tamil Nadu. It is resistant to grain mould disease of coriander. It matures in about 110 days with an average seed yield of 450 kg/ha.

Co-2: Coimbatore-2 variety was developed at Tamil Nadu Agricultural University, Coimbatore in 1982, through re-selection of P-2 culture of Gujarat. It is suitable for both *Rabi* and *Kharif* seasons

for saline, alkaline and drought prone areas of Tamil Nadu. It is dual purpose variety growing for both, seed as well as leaves. Its plants are erect and bear oblong, medium size seeds having dull colour with an average seed yield of 520 kg/ha. When it is grown for leaf purpose it gives 1000 kg /ha green leaves at 40 days crop growth stage.

Co-3: Coimbatore-3 variety was developed through pure line selection from ACC No. 695 of IARI, New Delhi at TNAU, Coimbatore. It was identified in the year 1991 for Tamil Nadu state. It is superior to both Co-1 and Co-2 in adaptability as well as seed production. It is suitable for both seed as well as leaf purpose. It is an early maturing type and matures in 85-100 days and gives 650-700 kg seed yield/ha. The plants are dwarf with oblong, medium bold, brownish yellow seeds containing 0.35-0.40 per cent essential oil. The variety is suitable for cultivation in both *Kharif* and *Rabi* seasons in Tamil Nadu. It is tolerant to wilt, powdery mildew and grain mould diseases of coriander.

CS-287: It was developed through re-selection of CS-6 ofA.P. for its better improvement. It has been developed for Tamil Nadu at TNAU, Coimbatore and suitable for both dryland as well as irrigated conditions of Tamil Nadu and Andhra Pradesh. Its plants are early maturing type and mature in 80- 100 days with 540-630 kg seed yield/ha. Seeds are oblong, medium in size having straw colour. It posses field tolerance to wilt and grain mould .

Sowing time: June-July (*Kharif*), September-October (*Rabi*)

Spacing: 20 x 15 cm (*Kharif*)) and 15 x 15 cm (*Rabi*)

Fertilizers and Manures: In corianderl0-15 tonnes of FYM + 30:40:20 kg NPK /ha should be applied for proper growth, development and quality yield. Under *Kharif*condition full dose of fertilizer may be added to the soil at the time of field preparation just before sowing. For *Rabi* N may be applied in three splits.

Seed rate:

Seed rate depends upon seed size, growth habit, irrigation availability (irrigated or unirrigated), soil type and availability of soil moisture at the time of sowing. Seed germination is better in irrigated conditions, which requires relatively less seed rate than rainfed conditions where seed germination is poor due to less availability of water in soil. The seed rate generally required is 10-12 kg per hectare for irrigated and 20 kg for rainfed cropping system

Seed treatment:

Coriander is propagated through seed (botanically fruits called schizocarp). Being bilocular each schizocarp has two mericarps and thus before sowing fruits are rubbed to split into two halves. After splitting the seeds should be treated with *Trichoderma* @ 4.0- 6.0 g/kg seed. After seed treatment, seed should be inoculated with Azotobacter and phosphate solubilizing bacteria.

Sowing method:

The crop is usually sown by broadcasting of seeds but line sowing is better which allows proper weeding, hoeing,application of pesticides etc. Seed depth should not exceed 2.5cm otherwise germination will be reduce. Soaking seeds in water for 8-12 hours before sowing hastens germination. The field should be prepared well in order to produce fine seed bed. For rainfed crop, the field should be prepared before the onset of monsoon so as to make seed loose to absorb maximum of moisture to give good germination.

Manures and fertilizers

The manures and fertilizers should be applied based on soil testing report. In general the organic manure should be applied three weeks before sowing of the crop so that they can be decomposed in soil. One third of N and full dose of P and K should be applied as basal dose at the time of last ploughing while preparing field and remaining 2/3rdN should be applied in two equal split doses as top dressing at 30 and 60 days after sowing.

Irrigation

For irrigated crop, depending upon temperature and soil type 3-6 irrigations are required in addition to those given for germination. For heavy soils only 3-4 irrigations are sufficient whereas for light textured soils about 6 irrigations are required. The critical stages for irrigation are seedling stage (30-40 DAS), grand growth period (50-60 DAS), flowering (70-80 DAS) and seed formation stage (90-100 DAS). Duration of these stages will mainly depend upon variety used (short/ long duration) and type of soil. Care should be taken that adequate moisture is available to crop after flower initiation, particularly at the time of seed formation. Stagnation of water is harmful for the crop; hence proper drainage must be provided especially where it is grown as *Kharif* crop.

Crop rotations

Crop rotation is an important agro technique which provides sustainability to the soil, with higher productivity of quality produce. The influence of insect-pests, diseases and weeds is also reduced by proper crop rotation. Some important crop rotations suggested are:

- Maize-Potato-Coriander
- Summer moong- Bajara- Coriander
- Rice- Coriander- Summer moong/ fallow
- Green gram/Black gram Coriander-Okra
- Cowpea-Coriander- Okra
- Cluster bean-Coriander- Summer maize.

Yield reducing factors: Though coriander occupies the first position in area and production among all the seed spices, yet the productivity is very low. The major reasons for low productivity of coriander are the biotic and abiotic stresses. The widespread introduction of high yielding cultivars and adoption of intensive crop management practices resulted in substantial increase in yields. Side by side it has also improved the conditions for insects, diseases, weeds, rodents and nematodes. All living organism, which causes loss to the crop in terms of yield and quality are called pests. Yield losses due to these pests ranges from 30-40%. Thus the role of plant health coverage in agriculture production cannot be overlooked. Like any other technology, the concept of plant protection is also changing.

Biotic stresses:

Weeds: Being a *Rabi* season irrigated crop, coriander is facing weed problem a lot. The weeds exert competition to the crop with respect to water, nutrients, space, light and air. The important weed flora generally found in coriander crop are: Bathua (*Chenopodium album*), Kharbathua (*Chenopodiummurale*), Sanji (*Melilotus indica*), Piyaji (*Asphodelustenuillolius*) and Krishan neel (*Anagallisarvensis*).

Weed management:

In North India the coriander is taken as a *Rabi* season crop. Where as in South India it is taken both in *Kharif* and *Rabi* season. The weed problems in crop thus differ with the season. Further the crop is slow growing up to 40-45 DAS, therefore crop need to be kept weed free up to 50 DAS. Two to three hand weeding and hoeing are necessary for effective management of weeds. Two weedings followed by hoeing should be practiced at 30 and 60 days after sowing. If required, third weeding can be done. During first weeding the plants should also be thinned to maintain proper spacing for ensuring recommended plant population, if plant population is higher in the field. Chemical control of weeds can be done with a pre plant application of the herbicides. In India the crop is mostly taken as rain fed crop (70-80%) and for weed control during the vegetative phase pre-plant

incorporation of Fluchloralin @ 0.75 to 1.0 kg/ha or per-emergence application of Oxyflurofen @ 0.15 kg/ha or Pendimethalin @ 0.75 to 1.0 ka/ha after dissolving in 400-500 litres of water is recommended. After chemical control of weeds, one had weeding at 50-55 DAS is necessary to ensure weed free condition till harvesting of the crop. Since coriander is taken on medium to heavy soils, summer ploughing is also advisable in the crop to alleviate the weed problem In areas where coriander is taken as an intercrop with gram, linseed or sugarcane the weed control measures should be taken keeping in view both the crops.

Diseases:

1. Powdery mildew:

This is one of the important diseases of coriander, which generally appears in all coriander growing areas. The disease is caused by *Erysiphepolygoni* . The disease symptoms appears as a white powdery mass on the leaves and twigs of the plants in initial stage and later on whole plant is covered with whitish powder. It generally appears in the month of February March and causes significant loss to the crop yield.

Management strategies:

- Early sowing of coriander is effective for management of powdery mildew.
- Application of sulphur dust @ 25kg/ha, spray with Wettable Sulphur suspension (0.1%) spray is alsoeffective against powdery mildew control in coriander. The spray should be repeated at 10-15 days interval if required.
- Seed treatment with Thiram proved effective in reducing severity ofthe disease and increased the seed

2. Wilt (*Fusarium oxysporiurnf*.sp. *coriandri*): Younger plants are more susceptible to wilt. Yellowing as well as drooping of leaves and terminal branches are symptoms of disease. The infected plant dries up due to wilting in later stage.

Management strategies:

- The pathogen is coriander specific, thus to follow crop rotation is an important tool for disease management.
- Solarization of soil during summer, use of disease free seed, seed treatment with Captan or Thiram @ 3.0g/ kg of seed should also be followed.
- Seed treatment with *Trichoderma viridae* @ 4g/kg seed is also effective in reducing wilt incidence in coriander.

3. Stem gall (*Protomycesmacrosporus*): The symptoms appear as galls on the stem, leaf stalk and peduncles. The seeds are deformed and the yield is reduced.

Management strategies:

- Seed treatment with Captafol 2g/ kg seed is effective in inhibiting seed borne infection with the disease.
- Spraying 0.1% Carbendazim or Captan 0.2%, 2-3 times at an interval of 10-15 days.
- Soil solarization and use of resistant varieties are effective for the management of disease.

4. Nematodes (*Meloidogyne incognita*):

Management strategies: Growing of resistant cultivars like RCr-41, Co-1, Co-2 is recommended.

Insects:

Coriander crops attracted large number of insect pests and pollinators during its crop growth in the field. It also attracts numbers of storage pests during storage of seeds. The appearance of pests started at early vegetative stages and lasted till the seed mature. Since this crop attract large number of natural enemies of the pests and pollinators, it is important to apply judicious use of insecticides to control the pests and prevent the loss of beneficial insects like predators/parasitoides/pollinators which is vital components of IPM.

Coriander aphid, *Hyadaphiscoriandri* (Das)

The coriander aphid is also known as *Moila*, *Chainpa* or *Manhu*. Coriander aphid *H. coriandri* recorded in all major growing areas of India. . This species is also major pest of fennel and dill crop. The Coriander aphid is most abundant on coriander crop during winter season particularly December to March. Females of *H. coriandri* give birth to young ones (nymphs) parthenogenetically and nymphs grow up through three nymphal instars for 4-5 days depending upon available host and environmental conditions. The entair life cycle is completed in 16 to 20 days. There are several generations complete in a year. Cloudy and wintry weather is quite favorable for raphid multiplication of this species of aphid. On coriander plant aphids colonize on leaves, tender apical shoots and umbels where both nymphs and adults suck cell sap and devitalize the plant. Infestation in early stages causes distortion in plant growth, yellowing of leaves and reducing their vigour. The heavy infestation of aphid on coriander occurred between December to march and cause the loss of more than 50% of yield in unprotected crop.

Thrips:

Thrips are tiny insects. It is also one of pests coriander crop. Amongst the species of thrips attacking seed spices, *Thrips tabaci* is the major specie found on most of the seed spice crops. Both nymphs and adults feeds on umbel. leaf sheath and stems of plants . Both nymphs and adults congregate in between the leaf sheath and stems of plants which results in drying of the leaves. Severe infestation results in drying of flowers and production of shriveled fruits

Mite:

Among the other sucking pests the tetranychidae mite *Petrobialatens* is another serious pest on coriander and cumin. It found infesting semi arid and arid region of Rajasthan. *P. lateens* have also been reported on coriander crop in southern part of India.The brown wheat mite, *Petrobialatens* was first reported feeding on coriander. It remains active during winter with peak activity in March. It is a minute, non webbing and swift moving mite and has a tendency to dislodge from the plant when disturbed. The larva, nymphs and adults feed on upper as well as the lower surface of leaves, leaf sheaths and floral parts. Infested leave started withering from top downwards. The plants become chlorotic due to loss of cell sap, resulting in poor seed formation. Heavily infested plants show sickly yellowish or bronzing appearance. The mites become serious pests only where excessive use of insecticides is made and they develop resistance to these chemicals faster than the insects.

Management of Aphids/Thrips/Mites

- Use botanicals Neem seed kernel extract (NSKE) 5.0%, Neem oil 2.0%, Azadirachtin 10000ppm @2.0ml/lire and bio-pesticides like *Verticillium lacanii*1x10^8 CFU's/gm5.0 g. /litre of water as foliar spray on the crops.
- For mite control use bio pesticide *Hirsutellsthompsoni*1x10^8 CFU's/gm5.0 g. /litre of water as foliar spray on the crops.
- There is no level claim of any insecticides in coriander crop. However in case of severe infestation need based use of chemical insecticides i.e.Emamectin benzoate @ 10 g ai/ha or Thiacloprid @ 0.24% orDimethoate 30EC @ 0.03% to prevent losses.

Seed wasp, *Systole albipennis* (Walker)

Systole albipennis is specific pest coriander and other seed spice crops. It causes the damage in field condition but the immature stage present inside the seed emerged at storage. The adult wasp is a phytophagous pests. It is a minute hymenopteran wasp, about 1-1.5 mm long, having transparent

wings on black coloured body. The larva damage the seed and survive inside the fruits. The infestation of this insect continue in the seeds till storage. Female adults lays eggs inside the developing seeds. The eggs hatches inside seed and developed larva feeds upon and destroys the embryo and/or endosperm consequently. Adult emerge out by making exit hole in the seed. They complete their life span within 25 days from egg to adult's stage. The immature stages present inside the seed after harvest emerged in storage condition and takes two to three months or even more. The newly hatched larvae feed upon developing fruits and destroys the embryo and/or endosperm which loss seed viability. The yield loss incurred approximately 30 percent in coriander. If infestation is more severe, the yield of coriander is above 50 percent

Management of Seed Wasp:

- Apply botanical products i.e. neem products NSKE 5% @ 5ml/lit, neem oil 2% otkaraj oil 2% is effective against this pest.
- Soil application of Karanj meal 500 kg/ha. + Spray of Karanj oil 2%.
- There is no level claim of any insecticides for seed wasp in coriander crop. However in case of severe infestation need based use of chemical insecticides i.e.Abamectin 1.9EC @ 2ml/lit or Thiacloprid @ 0.24% to prevent losses.

Table 1. IPM and IDM strategies

Stage	Pest / Disease	Practices to be adopted
Pre-sowing	Soil borne diseases, insect and nematodes	Deep summer ploughing. Follow crop rotation. Add well decomposed organic manure.
Sowing	Wilt & blight	Treat seed just before sowing with *Trichoderma viridae* or *T. hazianutn* @ 4 g/kg seed or treat seed with Carbendazim @ 2g/kg seed Select healthy and disease free seed.
	Nematode, diseases & Insects	Apply neem cake @ 150kg/ha Sowing should be completed within recommended time.
Vegetative	Wilt & stem gall	Avoid over watering. Maintain optimum moisture level. Adopt recommended plant spacing. Spray Carbendazium @0.1%.
	Aphids , whitefly and defoliator	Conserve *Coccinella, Chrysopides, Syrphid* fly etc). Release of *Coccinellids* @ 1000 beetles at 10 days interval. Spray 5% NSKE Spray Endosulfan (0.07%) need based

Reproductive stage	Powdery mildew	Spray of Dinocap (0.1%) or wettable Sulphur (0.25%) or dusting with Sulphur @ 20-25 kg/ha during flower initiation
	Stem gall, blight or grain mould	Spray Carbendazium @0.1%
Storage	Pest and disease	Store in gunny bags with moisture proof lining.

Table 2. Pest and disease tolerant / resistant varieties of coriander

S. No	Variety	Area of adoption	Tolerant I resistant to
1	RCr-41	Rajasthan	Resistant to stern gall and tolerant to powdery mildew.
2	RCr-435		Moderately resistant to stem gall and wilt.
3	RCr-446		Moderately resistant to stem gall and wilt.
4	RCr-20		Resistant to wilt, stem gall and nematodes.
5	CO-3	Tamil Nadu, Gujarat and Andhra Pradesh	Tolerant to wilt, powdery mildew and grain mould.
6	CS-287	Tamil Nadu	Tolerant to wilt, powdery mildew and grain mould.
7	GCr-1	Gujarat	Tolerant to wilt and powdery mildew.
8	GCr-2	Gujarat	Tolerant to wilt and powdery mildew.
9	Raj endraSwathi	Bihar	Moderately resistant to wilt, stem gall, aphids and weevil.
10	Sadhana	Andhra Pradesh	Tolerant to white fly, mites, aphids, wilt and powdery mildew.
11	Swathi		Tolerant to white fly, mites, aphids, wilt and grain mould.
12	Sindhu		Resistant to powdery mildew, wilt and aphids.
13	Pant Haritma	Uttar Pradesh	Resistant to stem gall, moderately resistant to wilt, aphid and weevil.

Abiotic stress

Frost: It damages the crop frequently in north India, particularly under unirrigated conditions. Burning of waste materials on the bunds of field in night is useful in protecting the crop during the frost prone period. Spraying of 0.1% sulphuric acid at flowering stage protect the crop from frost. Irrigation may be applied if possible.

Harvesting: Coriander crop matures in about 100-150 days of sowing depending upon varieties and climate. The green leaves are normally harvested 60-75 days after sowing and left for flowering and seed formation; whereas coriander crop grown exclusively for green leaves is harvested after 30-45 days of sowing. The coriander compound leaves with stem are prepared in bunches of desirable size for marketing. The stage of harvest depends upon the market requirement. For green coriander seeds, the crop is harvested when seeds are green and have attained full size. The green seed crop is dried under shade for retaining the green colour. Keeping in view, the market requirement, the crop can be harvested at yellow or brown colour of seeds. Delay in harvesting should be avoided, otherwise shattering and splitting of seeds may occur. Harvesting should be done by cutting the whole plant when 60% of seeds in main umbels attain desired size and colour and piled into small stacks in partial shade to dry for 2-3 days.

Yield:

An average seed yield of 4.5 to 6.0 q / ha can be obtainedfrom rainfed crop, whereas average seed yield of 8-12q/ ha along with additional marketable leafyield of about 5-7q/ha can be obtained from irrigated crop. The crop grown exclusively for leaf purpose yielded green leaves of about 50-80q/ha with 3-4 cuttings depending upon situations. Some improved varieties cultivated scientifically can give yield up to 27 q/ha of seed.

Processing For Green and dehydrated leaves:

Processing: The fresh greens consisting edible portions are the tender leaves and stem which are cut to length of about 5-7 cm above ground. The yellow, diseased and damaged leaves are trimmed off and weed plants and straw is culled during cleaning and dressing. Healthy and disease free leaves are tied into small bunches for the convenience in handling, transportation and marketing. The leaves of coriander are sun dried or dehydrated in a suitable dehydrator, for further use in off-season.

Storage: The fresh coriander leaves are highly perishable and deteriorates rapidly at temperature above 5°C. Therefore the fresh leaves bunch should be marketed soon after harvesting. The leaves can be sorted only for about 24-36 hours after harvesting under ambient condition. However in cold store at 0°C temperature and 90% relative humidity, the storage period can be extended for one week.

For Seed:

Harvested plants are dried in the sunlight for 1-2 days to bring the moisture level down to 18%. The dried plant is then trashed to remove the seeds. Seeds are further dried in the shade to bring

the moisture level down to 9%. Coriander seed is mainly processed into powder by crushing and the powder which enjoy an aroma, is used as food ingredient. Seeds which contain 0.1-1.5% of oil are used to extract essential oils.

Storage: The dried seed is filled in plastic bags or in gunny bags lined with plastic sheet. Each bag is sealed and stored under clean dry and ventilated place.

Grading:

Coriander is classified into different gardes based on quality of the produce. In general, coriander has been classified into grades like Badami (Brown), Eagle/ Scooter (Medium Green), Single/ Double Parrot (Green Colour).

For Powder:

The coriander seeds are washed, manually to remove dirt, soil and any other adhereing materials. It is then dried. Sun drying is widely used being cheaper. Drying is followed by powdering in disintegrator and micropulverizer. The powder is then shifted and tested according to standard procedures.

For Essential oil.

The mature dried seed of coriander are distilled to obtain the essential oil. Hydro or steam distillation method is generally used for extraction of essential oil. On an average, the dried seeds yield 0.1-1.7% volatile oil depending upon variety and location.

Cultivation of coriander under protected environment during offseason

Most of the seed spices including coriander are grown during *Rabi* season in a given set of agro-climatic condition. The seed spice crops are highly sensitive to the abrupt variations in climatic parameters. Frost and sudden development of the cold waves cause huge loss of the crop. The coriander crop can be taken for green leaves purpose under protected conditions given by different type of plastic nets, sheets etc. in the shape of tunnels, which can reduce the influence of extreme temperature. It was observed that plastic walk in tunnel and low pressure drip irrigation exhibited encouraging results. Most healthy plants with better growth and development, maximum number of umbels per plant, number of seeds per umbel and highest yield/ ha were obtained under plastic walk in tunnel and low pressure drip irrigation treatments. The minimum incidence of diseases and aphids was recorded under the same treatments.

Off-season crops always fetch high price in the markets due to its freshness. Moreover, in seed spices the quality aspect is very important parameter which affects it's competitiveness in

respect to their export value. Offseason coriander was grown at NRCSS Ajmer with 6 protection treatment namely control, white net, green net, black net (75%), black net (60%) and black net (50%). The coriander was grown on three different dates *viz*. 18thMarch, 2ndApril and 17thApril. Observations were taken on initial germination, completion of germination, plant height at 30 DAS, number of basal leaves per plant, number of leaves per plant and yield. Findings revealed the off season summer cultivation of coriander under white net and green net on all the dates of sowing exhibited best results with respects to germination, vegetative growth and leaf yield.

Products

The volatile oil is used chiefly as a flavoring agent for liquors, cocoa and chocolate industry and it is also valuable ingredient in perfumes. Good quality oleoresin can be extracted from coriander seeds. The oleoresin is used for flavouring, beverages, pickles, sweets and sausages. The other important product is Dania Dal, which is a major adjunct in Supari and Pan masala.

Export scenario of Indian coriander

India is the largest producer and exporter of coriander in the global market. The exports have increased significantly in the past few years due to strong demand from the overseas market. The changing pattern of food consuming or consuming of more spicy foods, especially in developed countries and the large populations of Indian living in these countries have resulted in good export market. The major importers for Indian coriander are Europe, US, Singapore and Gulf countries. Coriander export have touched 26,000 tonnes amounting to 110.25 crores of rupees during 2007-08.

Export oriented market centres of coriander

- Guntur, Varavakonda, Nandyal-(Andhra Pradesh)
- RamganjMandi,Baran, Kota-(Rajasthan)
- Thiruchirappilly, Virudhunagar-(Thamil Nadu)
- Davangore-(Karnataka)
- Varanasi, Jaunpur-(Uttar Pradesh)

Good agricultural practices

- Deep ploughing is to be done on bright sunny days during summer.
- Do not plank or irrigate the field just after ploughing.
- The field should be kept exposed to sun light at least for 2 to 3 weeks.
- Grow varieties suitable for the season or region.
- Grow only recommended pest / disease tolerant /resistantvarieties.

- Do not use seed without seed treatment with biocide chemicals.
- Always treat the seeds with approved chemicals for the control of seed borne disease.
- Don't grow in disease affected fields in subsequent years.
- Practice crop rotation in severely infected fields.
- Don't spray insecticides which are harmful to the honey bees.
- Spray during the evening hours when honey bees activities are minimum because honey bees are major pollinators in coriander crop.
- Don't grow coriander continuously for more than three years in the same field to avoid wilt disease.
- Survey the field regularly to monitor pest/ disease appearance.
- Don't use plant protection measures on calendar basis.
- Use cement concrete threshing yard or tarpaulin during processing of harvested material.
- The quicker the drying time, the better the final microbial quality ofthe product.

Table 3. Monthly operations to be done in coriander field for better production:

Name of Month	**Field operation**
July	Sowing of cluster bean for green manuring
August	Maintenance of green manuring crop.
September	Incorporation of green manure crop in the soil and field preparation. Apply 50% N and full dose of P& K as basal dose with FYM and / compost.
October	Incorporation of Methyl-Parathion 2% or Endosulfan 4%dust@25 kg/ha in soil for control of soil borne insect pest and the crop should be sown in 2ndfortnight of October
November	Sowing may also be done in 1stforth-night of October for late season crop. The irrigation should be given as per requirement. Apply 50% of remaining dose of N 30 DAS as top dressing in standing crop after first weeding and hoeing.
December	Weeding, hoeing and thinning is done during the period and irrigate the crop as per requirement. The top dressing of remaining N through urea should be done 60 days after sowing.
January	Irrigate the crop as per requirement and make the arrangement of smoke in the field to protect the crop from frost injury. Prophylactic spray of fungicide must be done to control blight in the crop.
February	Irrigate the crop as per requirement and prophylactic spray of fungicide and insecticide must be done to control fungal diseases and insects pests.
March	Irrigate the crop as per requirement and prophylactic spray of fungicide and insecticide must be done to control fungal diseases and insects

	pests.
April	Harvesting of the crop must be done at physiological maturity stage.
May	Threshing and winnowing of the crop is done during the period.
June	Cleaning, grading and bagging, of the crop is done during the period.

Uses

- In Asian folk medicine, coriander has been used to treat stomach problems, nausea, fevers, measles, colds, etc.
- It mask the unpleasant taste of various medicines.
- It contains next to no calories, it's a favourite herb of dieters.
- Add fresh, tender, young leaves to salads, and use as a garnish for fish and soups.
- Coriander seeds are a vital ingredient of curry powder.
- Use coriander seeds, either whole or ground, in pickles, soups, sauces, fruit desserts, such as stewed apples or prunes, and with all types of meat dishes.
- Add to mulled wine to impart a warm, summery flavour.
- Ground coriander is used commercially to flavour baked goods and processed meats such as hot dogs and sausages.
- The oil extracted from the seeds is used in the preparation of canned soups, sauces, candy, chewing gum, ice cream, liquors, gin, and even tobacco products.
- The roots are boiled and used in Thai-style, to flavour soups and chicken dishes.

Acknowledgement:

This matter has been collated from original research work carried out at NRCSS and from research reports of other centres and also from AICRP on spices. It includes the following references.

1. Bhati, D.S. (2005). Advances in production technology of Coriander. A course manual for winter school on Advances in Seed Spice Production at NRCSS, Ajmer during September,2-22,2005. p 196-200.
2. Parthasarathy, V.A., Shiva, K.N. and Johny, A.K.(2005). Research and Development in seed spices under AICRPS. A course manual for winter school on Advances in Seed Spice Production at NRCSS, Ajmer during September,2-22,2005.p 255-271.
3. Anandraj, M.V.A., Shiva, K.N. and Johny, A.K. (2007). Research and Development in seed spices under AICRPS. In Production, Development, Quality and Export of Seed Spices by S.K. Malhotra and B.B.Vashishtha(Eds.).p 370-395.
4. Malhotra, S.K. and Vashishtha, B.B. (2008). Package and Practices for production of seed spices. NRC on Seed Spices,Tabiji,Ajmer. pp. 98.