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Nutrition and Management of Seed Spices

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1. INTRODUCTION

Seed spices are annual herbs, the seeds and leaves of which are used for culinary, confectionery, perfumery, cosmetics and medicine. Though 17 seed spices are grown in India, most important among them are coriander, cumin, fenugreek and fennel. The productivity of seed spices in India is one of the lowest (545 to 1113 kg/ha) compared to other growing countries in the world. The present production is only a fraction of the potentially realisable yield with available knowledge and inputs. Nutrition and management of seed spices occupy a key place in the package of improved technology for augmenting productivity. This chapter reviews the information on major seed spices, viz., coriander, cumin, fenugreek and fennel with regard to cultivars, ecology, cultivation, fertilizer recommendations, uptake of nutrients and areas deserve further research.

2. CORIANDER

Coriander (*Coriandrum sativum* L.) is a native of Mediterranean region. It is one of the earliest spices used by mankind. The major coriander growing states in India are Rajasthan (34%), Madhya Pradesh (24%), Andhra Pradesh (16%) and Tamil Nadu (11%). Coriander is propagated by seed. The fruits before sowing are rubbed until the two meso carps are separated out and then sown. Each coriander growing area has a distinct cultivar/type which may be due to soil, climate and/or cultural differences.

2.1 Cultivars

A number of cultivars, distinguished by the name of the locality, are under cultivation. Thirteen important cultivars/variety with distinct features, which have already been released for cultivation by Agricultural Universities under the scheme of All India Coordinated Research Project on Spices (AICRPS), are given in Table 1. The yield varies depending upon variety and location. The CS-287 is specially suited for rainfed tract of Tamil Nadu, while RCr-41 a stem-gall resistant variety is preferred by farmers in stem gall endemic areas in Rajasthan. The oil content of fruits of some cultivars in the USSR and Mediterranean regions are high compared to those cultivars grown in India and, therefore, efforts are made to import exotic germplasms through National Bureau of Plant Genetic Resources (NBPGR). The Russian cultivar 'Lucs' reported to have given highest

Table 1 : Coriander varieties recommended for cultivation in different states in India

Variety	Yield (kg/ha)	State recommended for cultivation
Co-1	400	Tamil Nadu
Co-2	520	Tamil Nadu
Co-3	650	Tamil Nadu
CS-287	600	Tamil Nadu
Guj. Coriander-1	1100	Gujarat
Guj. Coriander-2	1450	Gujarat
Rcr-41	1200	Rajasthan
UD-20	1200	Rajasthan
Sadhana	1025	Andhra Pradesh
Swathi	855	Andhra Pradesh
Sindhu	1050	Andhra Pradesh
Rajendra Swathi	1300	North Bihar
DH-5	1400	Haryana

yield and essential oil (Purseglove *et. al.*, 1981). The cultivar 'CIMPO' S-33 (Central Indian Medicinal Plant Organisation, Bangalore), an introduction from Bulgaria, reported tall, late maturing with small seed to have given three times more yield, and essential oil content of about seven times more compared to the local cultivar (Anon., 1976; Dimri *et. al.*, 1977; Kumar *et. al.*, 1977).

2.2 Fertilizer Recommendations

Fertilizer recommendation for efficient and economic production assumes significance, particularly in the present context of two to three folds increase in fertilizer cost. Pillai and Boominathan (1975) reported that application of NPK at 20:40:20 gave 26 per cent increased yield (Table 2). Studies conducted in Gujarat demonstrated the response of coriander up to 60:60:30 kg NPK per hectare in soils poor in N and P, and medium to high in K status (Anon., 1979). Application of farm yard manure (FYM) at 25 tonnes per hectare together with the dose of NPK at 60:40:20 is ideal under Bihar condition (Anon., 1992a). Under Gujarat condition, it is reported that application of 25 tonnes of FYM together with 15 kg N, and 20 kg P as basal and 15 kg N as top dressing on 30 days after germination (DAG) is optimum (Anon., 1986b). Fertilizer response studies conducted at Jobner (Rajasthan) and Guntur (Andhra Pradesh) showed that application of N at 60 kg ha^{-1} in three equal splits of 20 kg each at sowing, 30 and 75 DAS gives maximum profit (Anon., 1993b). Bhati (1991), in a review of agronomic practices followed in seed spices, reported that in black cotton soil of Tamil Nadu coriander responded well for organic manure application at 10-15 tonnes ha^{-1} together with N and P at 20 and 40 kg/ha respectively. Application of K did not give positive response perhaps the soils are inherently rich in K.

Table 2 : Fertilizer recommendations for Coriander

Location	FYM (t ha^{-1})	Recommendations N	P_2O_5 (kg ha^{-1})	K_2O	Time of application	Reference
Gujarat		60	60	30		Anon. (1979)
	25	15	40	20		Anon. (1986)
	25	15	20	—	Basal	Anon. (1986b)
		15	—	—	30 DAS	
Rajasthan		20	—	—	At sowing	
		20	—	—	30-45 DAS	Anon. (1988)
		20	—	—	At flowering	
Tamil Nadu		20	40	20		Pillai and Boominathan (1975)
	10-15	20	40	—		Bhati (1991)
Bihar	25	60	40	20		Anon. (1992a)
		20	—	—	At sowing	
		20	—	—	30 DAS	Anon. (1982b)
		20	—	—	75 DAS	

DAS = Days after sowing.

2.3 Uptake of Nutrients

Seed spice crop absorb and remove large amount of major, secondary and micro elements from the soil. Not much information is available on the quantity of nutrients translocated and removed by the crop. No attention was paid on these lines. Further fertilizer trial in seed spices is of recent origin. Information on nutrient availability in soil due to application of fertilizer was also meagre. Investigations were, therefore, carried out at NRCS, Calicut by chemical analysis of important seed spices, viz., coriander, cumin, fenugreek and fennel to study the removal of major, secondary and micronutrients. The information is given in Table 9. Data showed that among the major nutrients, nitrogen (N) content is the highest, followed by potassium (K). Among the micronutrients, maximum content was iron (Fe) followed by zinc (Zn).

A crop of coriander yielding 631 kg per hectare of grain coriander removes about 12 kg N, 4.5 kg P_2O_5 and 11 kg K_2O (Table 9). The above data of uptake did not take into account, the nutrients removed by root system, aerial growth and foliage of coriander. It is quite evident from the above that removal of NPK is in the ratio of 2.7:1:2.4. The removal of K by coriander seed is almost equal to that of N. But if we look into the fertilizer recommendation to coriander, it is not in tune with the crop removal. If the total nutrient removed by root and shoot is also taken into account, the K fertilizer now recommended is inadequate for sustained production in the long run. The removal of micronutrients by coriander seed is substantial. Even though there are reports of sporadic deficiency of micronutrients, there is no schedule of micronutrient recommendation for coriander. Among the micronutrients, maximum removed is iron (88 g ha^{-1}) followed

by Zn (26 g ha^{-1}). For Rajasthan, which is the major coriander growing state in India, there is no schedule of recommendation of P and K. The same is the case for Gujarat. In the entire Rajasthan, there is no recommendation for K fertilizer application. A relook is, therefore, called in the fertilizer recommendation for a sustainable production of coriander.

3. CUMIN

Cumin (*Cuminum oyminum* L.) is believed to be a native of either Egypt or Syria or Eastern Mediterranean region. The States of Rajasthan (50%) and Gujarat (40%) are the major growers in India. In order to meet internal and export demand a production target of 1.6 lakh tonnes by the turn of century with an annual growth rate of 8 per cent is envisaged.

3.1 Cultivars

Five improved cultivars of cumin released by AICRPS centres from Gujarat and Rajasthan are given in Table 3. All these varieties are selections among the existing cultivars, and therefore, yield levels and oil content are much less compared to exotic varieties. The Gujarat variety MC-43 gives 34 per cent higher yield than S-404. MC-43 has greater capacity to survive under environmental conditions like water stress and disease incidence like fusarium wilt. Gujarat cumin gives 23 per cent higher yield than MC-43. It has better resistance against wilt, Gujarat cumin-2 gives 14 per cent higher yield and better tolerance against wilt disease. RZ-19 Rajasthan variety is high yielder having more tolerance to wilt and blight.

Table 3 : Cumin varieties recommended for cultivation in different states of India with their mean yield

Variety	Yield (kg/ha)	State where cultivation recommended
S-404	350	Gujarat
MC-43	580	Gujarat
Guj. Cumin-1	700	Gujarat and Rajasthan
RZ-19	500	Rajasthan and Gujarat
Guj. Cumin-2	700	Gujarat

3.2 Soils

According to Jansen (1981), a rich sandy loam is the best soil for growing cumin. The crop can tolerate salinity where other crops fail to grow (Bhati, 1991). Report from Rajendra Agricultural University, Bihar showed that loam, sandy loam or medium black soil with good drainage is the best (Anon., 1993b).

3.3 Management

Singh and Joshi (1964) reported that broadcasting of cumin seed is better over line sowing in getting high yields. Contrary to this proposition, the superiority of line sowing at 30 cm row spacing with a seed rate of 10-12 kg/ha was reported by Lal (1969), Chandola *et al.* (1978), Anon. (1971), Sharma (1972), Sharma and Agarwal (1978). However, Chowdhary (1986) could not get significantly higher yield due to line sowing under Rajasthan condition. Line sowing would definitely have the advantage over broadcasting for speedy hand weeding (Anon., 1978).

As regards time of sowing, 22 November to 15 December is the best (Chandola *et al.*, 1978). Broadcasting cumin in seed bed dimension of 2 × 2.5 m or line sowing in rows of 25 cm at 20 kg ha^{-1} is optimum (Jansen, 1981). In order to hasten germination seed soaking with potassium nitrate (100 ppm) for 24 hours is best (Maurya *el al.*, 1985). Under Rajasthan condition, adoption of 12 kg seed rate was advocated while under Gujarat condition, adoption of a higher seed rate of 15-20 kg was advocated (Anon., 1986a). However, under Udaipur condition, sowing during third week of November is optimum (Bhati, 1989).

Soaking of cumin seed for 24 hours prior to sowing and adopting a seed rate of 15 to 20 kg ha^{-1} with a spacing of 22.5 to 30 cm is optimum (Anon., 1993a).

It may be concluded that under Rajasthan condition, cumin should be sown at 22.5 cm row spacing using a seed rate of 12 kg ha^{-1}, while under Gujarat condition, a higher seed rate of 14 kg ha^{-1} is more beneficial.

3.4 Fertilizer Recommendations

Cumin responsed favourably to fertilizer application of N and P (Mishra, 1963; Singh and Josh, 1964; Sharma 1972; Sankhala and Mathur, 1980). However, Aiyadhurai (1986) opined that cumin did not respond favourably to application of NPK in soils rich in nutrients. Studies conducted at Anand by Jain (1957) showed that application of NPK at 25:20:20 gave positive response to cumin. Mishra (1963) reported that in Rajasthan, application of 20 kg P_2O_5 increased the yield of cumin. However, Barghava *et al.* (1966), Lal (1969), Chandola *et al.* (1980) and Fageria *et al.* (1972) reported higher yields due to application of N at 50 to 60 kg per ha. Singh and Joshi (1964), Sankhala and Mathur (1980), Niazi and Anees (1970), Sharma and Pandey (1981), and Bhati *et al.* (1987) sated that application of N at 20-30 kg per ha is optimum for cumin. Studies conducted in Gujarat has shown that application of FYM at 15-20 t/ha as a basal application followed by 15 kg P_2O_5 applied while drilling the seed followed by 30 kg N as top dressing in two equal splits during 30 and 60 day after sowing is the best (Anon., 1986a). Studies conducted in Rajasthan showed that among the nutrients, N is the most important element and is application at 15 kg as a top dress on 30th and 60th day after germination is optimum (Anon., 1993b). Fertilizer recommendation for different states in India are given in Table 4.

Table 4 : Fertilizer recommendation for cumin

Location	FYM (t ha^{-1})	Recommendations N	P_2O_5 (kg ha^{-1})	K_2O	Time of application	Reference
Gujarat		25	20	20		Jain (1957)
		50-60	—	—		Bhargava *et al.* (1966), Lal (1969)
		20-30	—	—		Chandola (1978) Sharma (1972) Sharma and Pandey (1981) Bhati *et al.* (1987)
Gujarat	15-20	—	15	—	While sowing	
		15	—	—	Top dressing 30 DAS	Anon. (1986a)
		15	—	—	Top 60 DAS	
Rajasthan		15	—	—	Top dressing 30 DAS	Anon. (1993b)
		15	—	—	Top 60 DAS	

3.5 Uptake of Nutrients

Nutrient composition of cumin is given in Table 9. It can be seen that maximum amount is of N (3.5%) followed by K (1.5%). Cumin is also a good carrier of calcium (1.0%) and micronutrients like Fe and Zn.

Cumin seed also absorb large amount of major, secondary and micronutrients from the soil for growth, development and sustained yield (Table 9). Out of the major nutrients removed by cumin seed yielding (545 kg ha^{-1}), nitrogen is the most (35 kg ha^{-1}) followed by K. The removal of Ca is also substantial (5.5 kg ha^{-1}). But at present, fertilizer recommendation is not in tune with crop removal of nutrients leave alone the removal by root system and the aerial shoot portion. The removal of micronutrients like Fe, Mn, Zn and Cu are also substantial (Table 9). But the existing fertilizer recommendation has perhaps not taken into account the crop removal of micronutrients.

4. FENUGREEK

Fenugreek (*Trigonella foenum graceum* L.) is the dried ripe fruit of a pulse used as a condiment rather than a pulse. It is a native of South-Eastern Europe and/or West Asia, and has been grown in India, parts of North African countries, Argentina, Southern France. The seed has a pleasantly bitter taste and a peculiar colour, odour and flavour. In India, Rajasthan (84%) and Gujarat (15%) are the major producing states followed by Uttar Pradesh (1%). To achieve the demand an annual growth rate of 9% is envisaged.

4.1 Cultivars

A number of local varieties are available for cultivation. But their productivity is low. AICRPS funded projects running in different State Agricultural Universities (SAUs) or by their own programme release five high yielding high quality varieties (Table 5) for cultivation in different States. Their yield limits ranging from 680 kg/ha (Tamil Nadu variety) to 1600 kg ha^{-1} (Haryana). Variety Co-1 is a dual variety, leaves used as a vegetable and seeds as a spice. RMt-1 gives bold seeds of typical yellow colour. It is moderately tolerant to root rot and powdery mildew and gives 1560 kg ha^{-1}. Co-1 is a dual purpose variety of Tamil Nadu with lower incidence of root rot. The RMt is a medium maturing variety while Lam Sel.1 is an early maturing variety Rajendra Kanti and HM-57 are long duration varieties and high yielders.

Table 5 : Fenugreek varieties recommended for cultivation in different states of India with their mean yield

Variety	Grain yield (kg/ha)	States recommended for cultivation
Co-1	680	Tamil Nadu
Rajendra Kanti	1250	Bihar
RMt-1	1560	Rajasthan
Lam Sel.1	740	Andhra Pradesh
HM-57	1600	Haryana

4.2 Soils

Fenugreek is grown on well drained loamy soils with irrigation. The crop is also grown in heavy black cotton soil as a rainfed crop in the early season. Singh and Joshi (1960) opined that fenugreek comes up well in loamy soil, but it can also be grown in heavy soils as well as sandy soil. According to Habit *et al.* (1971), fenugreek is fairly tolerant to salinity. The crop respond favourably to fertilizer application in all types of soils.

4.3 Management

Fenugreek is propagated by seed and the straw is used as a rich source of proteins for animals. AICRPS has so far released five fenugreek varieties for cultivation which is given in Table 8. Co-1 is a dual purpose variety used for seed, vegetable and fodder purpose. Fenugreek leaves are rich in protein and contains about 18-40 per cent protein at different stages of growth.

The states of Rajasthan (84%) and Gujarat (15%) are the major growers of fenugreek. Depending upon the agroclimatic conditions, the crop is grown during October-November (Anon., 1990).

Studies on optimum time of sowing showed that first week of November is the best and the crop can be grown both as broadcasted as well as line sown (20-30cm) crop (Rathore, 1980; Bhati, 1988).

Treating the seed with rhizobium culture enhanced the germination and adopting a seed rate of 30-35 kg ha^{-1} was optimum (Bhati, 1991). However, in Tamil Nadu, a lower seed rate of 20 kg ha^{-1} was recommended (Anon., 1993a).

Clipping of leaf is a practice followed in fennel growing areas. Clipping if limited to two at 50 and 80 DAS is best and did not affect seed yield (Devendran, 1980). Studies conducted under AICRPS at Jobner (Rajasthan) showed that sowing during the first fortnight of November by adopting a spacing of 30 cm between rows and 10 cm between plants in the row is optimum (Anon., 1993a).

4.4 Fertilizer Recommendations

According to Singh and Joshi (1960), fenugreek responsed favourably to application of NPK at 25:25:50 for obtaining a good crop. Soils that are deficient in P, and higher dose of P is favoured and application of NPK at 20:60:30 was optimum (Anon., 1979). In Rajasthan, application of N and P at 20 and 50 kg per ha recorded higher yield (Rathore, 1980). According to Pareek (1983), application of 20 kg N and 40 kg P_2O_5 per ha or ten tonnes per ha of FYM was effective. Studies on the effect of N and P at a constant level of K showed that, under Tamil Nadu condition, application of N and P at 50 and 25 kg ha^{-1} was effective (Periyasamy, 1981). Studies conducted at AICRPS centres in Rajasthan and Gujarat showed that application of FYM at 10 t/ha at the time of field preparation followed by application of NP at 20 and 40 kg ha^{-1} was effective. Studies conducted at Bihar showed that application of NPK at 20:60:40 kg ha^{-1} was optimum (Anon., 1992a). Fertilizer recommendations are given in Table 6.

Table 6 : Fertilizer recommendations for fenugreek

Location	FYM (t ha^{-1})	Recommendations N	P_2O_5 (kg ha^{-1})	K_2O	Time of application	Reference
		25	25	50		Singh and Joshi (1960)
Gujarat		20	60	30		Anon. (1979)
Rajasthan		20	50	—		Rathore (1980)
Tamil Nadu		50	25	—		Periasamy (1981)
	10 or	20	40	—		Pareek (1983)
	25	20	20	—	Basal	
		20	—	—	Top dressing 30 DAS	
Bihar		20	60	40		Anon. (1992a)

4.5 Uptake of Nutrients

Composition of fenugreek seed is given in Table 9. Fenugreek seeds contain maximum amount of nitrogen (3.5%) compared to the other three grain spices. The

content of K and Ca were almost at par. The seeds also contain maximum amount of zinc (173 mg kg^{-1}).

A crop of fenugreek yielding one tonne of seed, the ratio of absorption of NPK is 2:1:2. The uptake of nutrients like Ca, Fe and zinc is also fairly high compared to other elements.

Studies indicate strongly that, in order to support sustainable high and profitable yields, not only N and P, but also K, Mg and micronutrients, particularly Zn, should be included in the fertilizer schedule.

5. FENNEL

Fennel (*Foeniculum vulgarae* Mill.) is believed to be a native of Mediterranean countries and is cultivated in that region and also in Romania and India. It is used as food additive and a medicine. In India, the crop is cultivated mainly in Gujarat (76%) and Rajasthan (20%) followed by Uttar Pradesh (4%) (Table 3). To meet internal and export demand by 2000 AD, a target of 50 thousand tonnes has been set. To achieve this, an annual growth rate of 12 per cent is envisaged.

5.1 Cultivars

Fennel is also propagated by seed. It is the second important spices crop of Gujarat. The four important cultivars released by AICRPS centres based in Gujarat and Tamil Nadu are given in Table 7. A local variety, UF 32 (Lucknow type), is identified as best for masticatory purpose. Variety S-7-9, PF-35 and Guj. Fennel-1 are long duration and can be grown as transplanted/direct seeded crop and gives 20 per cent more yield than local.

Table 7 : Fennel varieties recommended for cultivation

Variety	Grain yield (kg/ha)	States for cultivation
S-7-9	1000	Gujarat
PF-35	1280	Gujarat
Guj. Fennel-1	1700	Gujarat
Co-1	570	Tamil Nadu

5.2 Soils

Fennel is grown in a variety of soils. No systematic study has been made on the ideal soil requirements for fennel. In Gujarat, which is the major grower of fennel, the crop is grown in deep black to medium black clayey loam soil by utilising the residual soil moisture. In sandy loam to clayey loam soils, the crop is grown as a transplanted crop under irrigation during *rabi*. In Rajasthan, fennel is grown mainly in sandy loam to clayey loam by utilising the residual soil moisture during *rabi* as a cold weather crop.

It is also grown in friable alluvial and sandy loam soils of Rajasthan. Badly drained and very alkaline soils are not suited for fennel.

5.3 Management

Fennel is yet another cold weather crop come up well under dry and mild cool climate, and thrive excellently well in North India and also to some extent in the hilly regions of South India. Studies on the identifying optimum time of sowing showed that October-November is best. Under North Indian condition, it can be sown in the hills during March-April (Pruti, 1976).

Fennel is grown both as broadcasted as well as transplanted. Soaking seed prior to sowing improve germination (Pateland Jaisani, 1974). It is grown both as broadcasted and line sown crop.

For Punjab, last week of October is better than November and late sowing results in lower yield and lower recovery of oil (Randhawa *et al.*, 1981a).

For Rajasthan, first week of October is the best for sowing (Bhati *et al.*, 1984; Bhati and Agarwal, 1986). Sowing after 30 October resulted in uneconomic yield (Kulhari and Bhari, 1986). Fennel as a transplanted crop is very profitable both in Gujarat and Rajasthan. For transplanted crop, seeds are sown and nursery raised during May-June and seedling of one and half to two months old are transplanted in the main field in August-September at a spacing of 60-80 cm or even up to 1 metre in rows and keeping 40-80 cm spacing between plants within row (Bhati *et al.*, 1984). For transplanted crop, seed rate adopted is 3-4 kg ha (Bhati, 1991).

Nursery beds of 3 × 0.5 m are prepared, seeds are broadcasted by June 15 for *kharif* fennel while in *rabi* fennel, 15 August is the optimum time of sowing (Anon., 1986a).

Fennel comes up well in well drained loam to loamy clay soil which are rich in plant nutrients and lime (Joshi, 1961). In all cases, heavy soils are preferred than light soil perhaps due to high retention capacity of soil moisture and nutrients.

5.4 Fertilizer Recommendations

There are only few reports on the nutritional requirement of fennel. According to Randhawa *et al.* (1981b), fennel responded to application of N and P at 100 and 40 kg/ha. Afridi *et al.* (1983) reported NPK at 90:60:90 as optimum. Studies conducted using organic and inorganic fertilizers which were compared with no fertilizer showed positive response to manuring compared to no manures (Anon., 1993c).

Muhlenberg (1966) reported favourable response to fennel due to application of nitrogen at different levels. Randhawa and Gill (1985) recorded favourable response due to application of N at 50 kg/ha. Bhati *et al.* (1988) reported that broadcasted fennel responded only up to 45 kg N/ha.

The effect of split application of N (25 kg each) as basal and at 60 DAS to fennel was reported by Gill and Sharma (1986). The response of fennel to application of micronutrients like Zn and B along with application of N at 45 kg and P at 50 kg was reported from Rajasthan and Bihar (Anon., 1983, 1986a). Fertilizer recommendations are given in Table 8.

Table 8 : Fertilizer recommendation for fennel

States	FYM (t ha^{-1})	Recommendations N	P_2O_5 (kg ha^{-1})	K_2O	Time of application	Reference
Punjab		100	40	—		Randhawa *et al.* (1981b)
U.P.		90	60	90		Afridi *et al.* (1983)
Gujarat	25	60	80	—	Basal in nursery	
	20	40	60	—	Basal at transplanting	
		30	—	—	30 days after trans-planting	
		30	—	—	60 days after trans-planting	
North Gujarat	25	15	30	—	As basal	Anon. (1986a)
		15	—	—	Top dressing with 0.6% Zn, 0.2% B as foliar at 30 days	
		15	—	—	Top dressing with 0.6% Zn, 0.2% B as foliar at 60 days	
		25	—	—	Basal	Gill and
		25	—	—	30 DAS	Sharma (1986)
Bihar		60	40	20		Anon. (1992a)
Rajasthan		90	—	—	N in 3 equal splits	Anon. (1991)
Gujarat		90	45	—		

5.5 Uptake of Nutrients

The nutrient composition of fennel is given in Table 9. Data showed that, among major nutrients, N is the highest (2.5%) followed by K (1.6%). Fennel is also a very good source of Ca (1.7%) and Mg (0.55%) as well as micronutrients. It is a very rich source of Fe, Mn, Zn and Cu (261, 54, 60 and 19 mg/kg respectively) (Table 9).

The uptake and removal of nutrients by fennel seed is given in Table 9. On an average, an irrigated fennel crop yielding 1113 kg ha^{-1} removed about 27 kg N, 11.2 kg phosphorous and 21 kg potash from one ha. The uptake of secondary and micronutrients are given in Table 9. There are reports that in a transplanted and irrigated crop of fennel,

Table 9 : Nutrient concentration and uptake of nutrients by seed spices

Seed spices	Concentration								
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu
	(g 100 g^{-1})						(mg kg^{-1})		
Coriander	1.9	0.31	1.5	0.81	0.25	139	25	41	15
Cumin	3.4	0.38	1.5	1.0	0.22	128	30	48	16
Fenugreek	3.5	0.36	1.2	1.4	0.18	173	14	39	12
Fennel	2.5	0.44	1.6	1.7	0.55	261	54	60	19

	Uptake of nutrients									
	Yield	N	P_2O_5	K_2O	Ca	Mag	Fe	Mn	Zn	Cu
		(kg/ha)						(g/ha)		
Coriander	631	12	4.5	11	5.1	1.6	88	16	26	11
Cumin	545	18	4.7	10	5.5	1.2	70	16	26	9
Fenugreek	1000	35	8.2	14	14.0	1.8	173	14	39	12
Fennel	1113	27	11.2	21	18.9	6.1	290	60	67	21

the nutrient absorption must be related with rate of stem elongation and rate of umbel formation yield. The average amount of micronutrients absorbed and removed by a fennel seed yield of 1113kg (Table 9) showed that fennel absorbs all the micronutrients like Fe, Mn, Zn and Cu compared to other three seed spices diseased. The response of fennel to application of micronutrients are reported (Anon., 1992). Spraying of Zn (0.3%) and B (0.1%) has been recommended from Rajasthan and Gujarat to augment productivity of fennel (Anon., 1992).

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