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Nutrients uptake pattern in some important cultivars of cumin for nutritional budgeting

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Abstract

The present investigation was carried out to assess the nutrient uptake pattern in five cumin cultivars ie GC-2, GC-3, GC-4, AC-167 and AC-01-3 under lower to medium fertile soil (Typic Haplustepts) of semi-arid region of Rajasthan. Results revealed that uptake of N, P, S and micronutrients were highest in GC-4. However, K uptake was highest in GC-2 among all the cultivars. N, K and S uptake was least in AC-01-3 and P in GC-2. However, least uptake of Fe, Zn, Mn and Cu was in AC-01-3, GC-3, GC-3 and AC-01-3, respectively. Uptake ratio indicates that N requirement of crop was highest among the macro and secondary nutrients which was 4.3 times to P; 1.3 times to K and 10.8 times to S. Fe requirement was highest among the micronutrients, which was 19.9 times to Cu, 11.5 times to Zn and 4.5 times to Mn. Mean value of N uptake partitioning for farm gate budgeting indicated that more than 50 per cent nitrogen went off from the farm and rest of N could be recycled by the crop residues. However, more than 50% P and K could be recycled on the farm and rest went out from the farm. More than 60% of S could be recycled and about 36% went out from the farm. In case of micronutrients, >50% of Fe and Mn went out of farm and rest can be recycled, whereas >50% Zn and Cu can be recycled at the farm and rest amount went out from the farm.

Key words : Cumin cultivars, macro-nutrients, micronutrients, nutrient uptake, uptake ratio, nutrient budgeting.

Introduction

A nutrient budget quantifies the amount of nutrients imported to and exported from a system. For a sustainable crop production, inputs and outputs budget should be equal. Based on the availability of data and purpose, nutrient budgeting can be done at various scales, ie a farm, a village, a state, or a country. There are three types of nutrient budgeting ie. A farm-gate nutrient budgeting (accounts for nutrient imports and exports relative to farm), A soil surface nutrient budgeting (accounts for all nutrients that enter the soil surface and leave the soil through crop uptake) and a soil system budget is the most comprehensive type of nutrient budget because all nutrient inputs and outputs in a given area of interest are included in the budget. The goal of nutrient budgeting is to help farmers for choosing and implementing best management practices (BMPs) to economize crop production and reducing the surplus of nutrients resultant reduction in pollution potential (Shober *et al.*, 16). The purpose of nutrient budgeting is also to educate extension workers, environmental management advisors, and governmental agency staff responsible for precision agriculture. Some of the nutrients like N as nitrate and micronutrients as heavy metals are responsible for water pollution and diseases caused by the drinking water. Most of the nutrients caused the eutrofication in water bodies and changes in lake or pond ecosystem. Most importantly reduction in fertilizer and other inputs and judicious use of resources, to reduce potential nutrient losses from agricultural ecosystem, nutrient run-off and leaching, volatilization, GHG emission etc should be taken care. Besides that we should also understand nutrients transformation and cycle within, and transport out to urban from agricultural systems (Onema *et al*., 10). Nutrient budget, which describes nutrient stocks and flows as related to different land management systems is a powerful tool in determining present and future productivity of agricultural land, as well as undesirable environmental effects such as nutrient mining and pollution (Smaling and Fresco, 18). Therefore, fertilizers should be applied as per the nutrient requirement of crop cultivars and time of application on the basis of crop duration for maximum nutrient use efficiency and higher yield as well as environment concern.

Cumin is an important seed spices gown in India and also worldwide including Egypt, Pakistan, Iran, Italy, Syria and Turkey. In India, the cumin growing states are Gujarat and Rajasthan including some parts of Madhya Pradesh and Uttar Pradesh. Though the nutrient requirement of

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this crop is low yet the nutrient budgeting is essential as it grows in poor soils of arid and semi-arid regions and information on aspects are meager. The stover of this crop is not palatable for cattle as fodder and could be recycled by composting. Growing demand of cumin in world market, it is essential to calculate nutrient requirement as well as budgeting for judicious use of fertilizers and manures to avoid over and under use.

Materials and methods

Location and climate

The field experiments were carried out under the Typic Haplustepts during *Rabi* season of 2007 – 2008 and 2008 – 2009 at National Research Centre on Seed Spices, Tabiji, Ajmer, Rajasthan, India. This was laid between 74° 35'39" to 74° 36' 01"E longitude and 26° 22'12" to 26° 22' 31" N latitude. Climate of the Ajmer area characterized as semi-arid. The average annual rainfall of the area is 536 mm and most of it (85-90%) received between June to September. July and August are most rainy months contributing 60.0% of the average rainfall. The moisture control section remains dry for more than 90 cumulative days and hence moisture regime classified as Ustic. The mean annual temperature is 24.5 to 25.0°C. January is the coolest month of the season and temperature remain around 7.0°C. Currently frost is also occurring in this month with changing climatic pattern (Singh and Shyampura, 17).

Treatments and cultural practices

The treatments consisted of three varieties of cumin viz GC-2, GC-3, GC-4, and two elite genotypes AC-167 and AC-01-3 were arranged in a Randomized Block Design (RBD) with four replications. Among these varieties, GC-4 has tolerance to diseases like wilt. Seeds of the crop varieties were sown in the 30cm line to line apart and distance from plant to plant was maintained at 10 cm. Cultural practices were uniformly followed during the growing seasons in both the years. The cultivars were harvested as and when matured as these belong to bit different maturity groups. After harvest, seeds were separated from the straw by beating bundles thereafter winnowing.

Soil analysis

Soil samples were collected from the surface (0-15 cm depth) before sowing seed of both year crops. Samples were air dried and powdered with wooden mortar and pestle and passed through a 2 mm stainless steel sieve. Experimental soil was analyzed for texture (International Pipette Method), EC and pH (Richards, 15), organic carbon content by rapid chromic titration (Walkley and Black, 21), available N by alkaline permanganate (Subbiah and Asija, 19), available P by 0.5 M $NaHCO_3$ extractable P (Olsen, *et al*., 11), available K by 1N NH_4OAc extracts method (Jackson, 7).

Texture of experimental soil was sandy loam. Soil EC, pH and organic carbon were 0.34 dSm^{-1}, 8.6 and 0.22%, respectively. However, soil available N, P and K were 98.9, 7.8 and 250 kg ha^{-1}, respectively. Micronutrient status like iron, zinc, manganese and copper of the soil was 7.5, 3.5, 25.5, 1.8 kg ha^{-1}, respectively. Soil calcium content was 8.5 per cent.

Plant analysis

The plant samples were collected after the harvest of all the crop cultivars and their replications. Plant samples were successively washed with tape water, 0.1 M HCl and distilled water and dried at 70°C. After proper drying samples were powdered in wily mill and passed through the 20 mesh steal sieve. Nitrogen was estimated by Kjeldahl method (Piper, 14). The samples were digested in nitric and perchloric acid (10:4) for the estimation of P by Venado-molybdo yellow colour method (Chapman, and Pratt, 4) and K by flame photometer. Sulphur was estimated by CHNS analyser and micronutrients by Atomic Absorption Spectrophotometer.

Statistical Analysis

The data of both the years were analyzed by ANOVA and treatment differences were expressed for Least Significant differences (LSD) at 5% probability to determine the significance among the treatment means (Cochran and Cox, 5).

Results and discussion

Nutrient uptake/crop requirement for soil surface nutrient budgeting

Total uptake by the crop cultivars

For the soil surface nutrient budgeting, total removal by the aerial part of the crop has to be assessed for surface application of nutrients to meet out the requirement of crop. It can be inferred from the fig-1 that highest N and K uptake was in GC-4 and GC-2, respectively and was least in AC-01-3. However, P and S uptake was highest in GC-4 and least in GC-2 and AC-01-03, respectively (Fig. 2). This was because of higher content of P and S as well as more plant biomass in these cultivars. Irrespective of cultivars, average removal of N, P, K and S were 23.8, 5.6, 18.3 and 1.7 kg ha^{-1} respectively.

The entire four micronutrients uptake was more in GC-4 among all the cultivars (Fig. 3 and 4). This might be due to the fact that higher biomass production by this cultivar under Ajmer conditions leads to higher uptake. However least uptake of Fe, Zn, Mn and Cu was in AC-01-3, GC-3, GC-3 and AC-01-3, respectively. Moreover, mean uptake of Fe, Zn, Mn and Cu was 418.2, 36.3, 92.9, and 20.8 g ha^{-1}, respectively. The highest uptake of Fe among the micronutrients may also be attributed by high lime content in experimental soil along with higher pH, iron turns into physiological inactive which create hunger even at higher accumulation in plant tissue (Aishwath, 1). Pathak *et al* (13) calculated the budgets of N, P, and K at national level for 2000–2001 taking into consideration the inputs through inorganic fertilizer, animal manure, compost, green manure, leguminous fixation, non-leguminous fixation, crop residues, rain and irrigation water and outputs through crop uptake and losses through leaching, volatilization and denitrification.

Fig. 1. N and K uptake by cumin cultivars for a soil surface nutrient budgeting

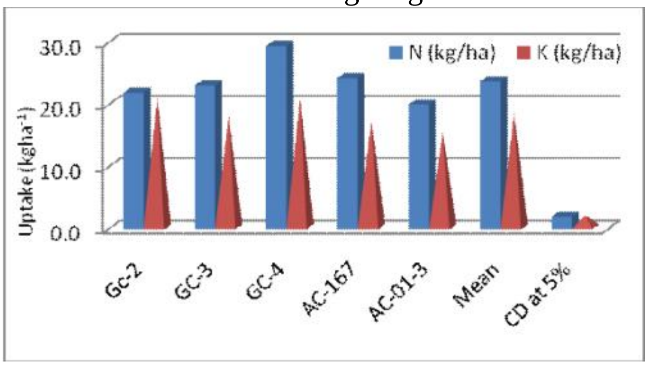
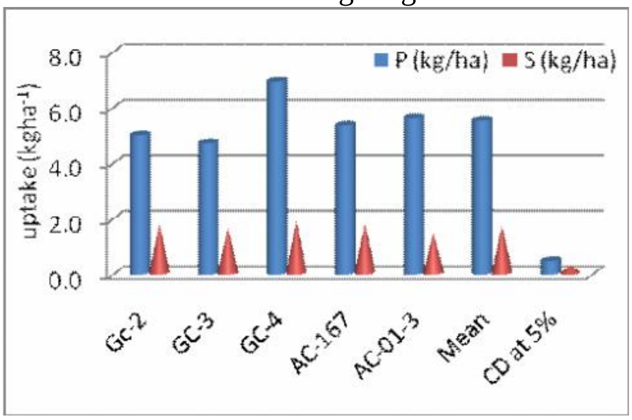


Fig. 2. P and S uptake by cumin cultivars for a soil surface nutrient budgeting



Nutrient uptake ratio

It is very much essential to assess the proportion of different nutrients taken up by the crop for input budgeting. Data on uptake ratio of nutrients given in table 1 indicated that N required 4.0 times higher than P, 1.3 times to K and 14 times to S. However, K uptake was 3.3 times higher than P and 10.8 times to S. Among the macronutrients, N requirement was highest than P and K. S requirement of cumin was 3.0-15.0 times lower than macronutrients obviously being a secondary nutrient. For N and P budgeting, Panda *et al.* (12) observed positive balance of P in the long-term experiments in rice-rice systems in the treatments with N and P application. For the budget of nutrient application ratio in major states have N: K wider than 4:1, which is accepted as balanced nutrient use ratio in the country. For Haryana this value is about 80:1 and for Punjab it was 40:1 (FAI 6).

Fig. 3. Fe and Zn uptake by cumin cultivars for a soil surface nutrient budgeting

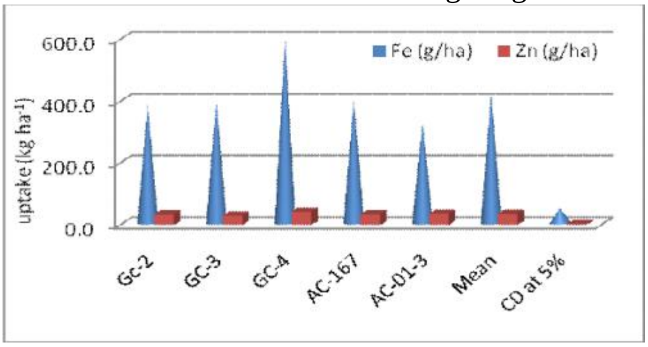
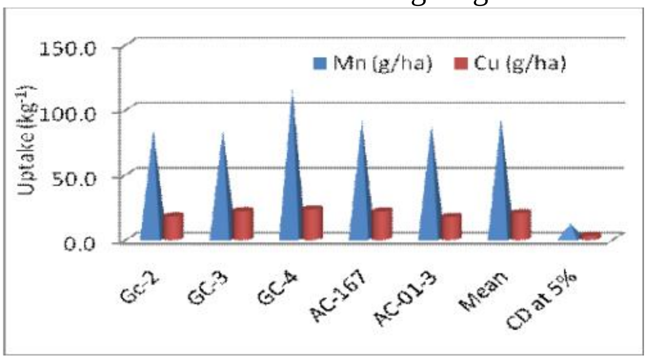


Fig. 4. Mn and Cu uptake by cumin cultivars for a soil surface nutrient budgeting



In case of micronutrients, 11.5 times more Fe required by the cumin, 4.5 times to Mn and about 20 times to Cu (Table 2). Mn required 2.6 times more than Zn and 4.5 times to Cu. However, Zn required about double than the Cu. This indicated that Fe requirement of cumin is highest and Cu requirement is least among the micronutrients. Benbi and Biswas (3) studied the P and K balance in maize-wheat cropping system and they found that P uptake by wheat was about 1.5 times to that of maize, whereas K uptake by wheat was only 1.1 times to that of maize. Hence, there is a need for modifying the existing K fertilizer recommendations to compensate for gradual loss of native soil K fertility at Ludhiana (Punjab).

Per cent removal of macro and secondary nutrients for farm gate budgeting

Mean value of N uptake per cent given in table 3 indicated that more than 50 per cent nitrogen went off from the farm and rest could be recycled through the crop residues. It

Table 1. Uptake ratio of macro and secondary nutrients in cumin cultivars

Cultivars	N/P	N/K	K/P	N/S	P/S	K/S
GC-2	4.4	1.1	4.1	12.5	2.9	11.8
GC-3	4.9	1.3	3.7	14.2	2.9	10.9
GC-4	4.2	1.4	3.0	15.7	3.7	11.0
AC-167	4.5	1.4	3.2	13.6	3.0	9.5
AC-01-3	3.6	1.3	2.7	14.2	4.0	10.8
Mean	4.3	1.3	3.3	14.0	3.3	10.8

was because of higher N content in seed than the stover. However, more than 50% P and K could be recycled on the farm and rest went out from the farm. More than 60% of S could be recycled and about 36% went out from the farm. Maximum sulphur could be recycled among the macro and secondary nutrients and least went off from the farm. This might be due to the fact that higher content by AC-167 and AC-01-3, respectively from the farm by these cultivars among all the cultivars. In case of K and S, highest amount went off by the cultivar GC-4 and AC-01-3 from the farm gate, respectively. However, highest K and S can be recycled by the cultivar GC-2. Aishwath and Anwer (2) reported that high yielding coriander cultivars removed higher N, P and K and uptake

Table 2. Uptake ratio of micronutrients in cumin cultivars

Cultivars	Fe/Zn	Fe/Mn	Fe/Cu	Mn/Zn	Zn/Cu	Mn/Cu
GC-2	11.1	4.3	20.9	2.6	1.9	4.8
GC-3	12.8	4.7	17.7	2.7	1.4	3.7
GC-4	13.8	5.2	25.0	2.7	1.8	4.8
AC-167	11.2	4.4	18.1	2.6	1.6	4.1
AC-01-3	8.6	3.7	18.1	2.3	2.1	4.9
Mean	11.5	4.5	19.9	2.6	1.8	4.5

of sulphur in stover and stover produced more than seed. High yielding traits will remove more of nutrients and exportable from the farm and this should be supplied in the ratio exported or retained (Pathak *et al.,* 13). Therefore, nutrient use efficiency is required to improve by various means (Ladha *et al.,* 9).

Maximum amount of N and P went off from the farm by the genotype AC-01-3 and GC-2, respectively among all the cultivars/genotypes. Highest N and P could be recycled

partitioning could be decided by the exportable part of crop for farm gate budgeting. Kikon *et al* (8) did the nutrient budgeting with the combine use of organic and inorganic fertilizers under inter cropping of patchouli in coconut based farming system. They have calculated the nutrient balance, based on the input (by fertilizers and manures) output (uptake by the crops) ratio of N, P and K via organic and inorganic means.

Table 3. Per cent macro and secondary nutrients for a farm-gate nutrient budgeting

Cultivars	N uptake (%) for		P uptake (%) for		K uptake (%) for		S uptake (%) for	
	Consu	Recyc	Consu	Recyc	Consu	Recyc	Consu	Recyc
GC-2	49.4	50.6	49.4	50.6	41.0	59.0	29.2	70.8
GC-3	51.8	48.2	46.0	54.0	49.4	50.6	37.3	62.7
GC-4	52.7	47.3	47.7	52.3	52.8	47.2	29.8	70.2
AC-167	46.3	53.7	47.6	52.4	49.4	50.6	47.3	52.7
AC-01-3	53.8	46.2	40.8	59.2	49.8	50.2	38.2	61.8
Mean	50.8	49.2	46.3	53.7	48.5	51.5	36.4	63.6
CD at 5%	2.2	2.2	3.2	3.2	2.73	2.73	5.88	5.88

Consu = Consumable, Recyc = Recyclable

Table 4. Per cent micro nutrients for a farm-gate nutrient budgeting

Cultivars	Fe uptake (%) for		Zn uptake (%) for		Mn uptake (%) for		Cu uptake (%) for	
	Consu	Recyc	Consu	Recyc	Consu	Recyc	Consu	Recyc
GC-2	58.6	41.4	56.4	43.6	49.7	50.3	36.4	63.6
GC-3	59.5	40.5	40.2	59.8	53.8	46.2	35.7	64.3
GC-4	59.7	40.3	42.0	58.0	51.8	48.2	42.4	57.6
AC-167	54.4	45.6	45.2	54.8	51.3	48.7	34.9	65.1
AC-01-3	53.0	47.0	48.4	51.6	50.8	49.2	40.3	59.7
Mean	57.1	42.9	46.4	53.6	51.5	48.5	38.0	62.0
CD at 5%	3.6	3.6	4.4	4.4	5.6	5.6	6.7	6.7

Consu = Consumable, Recyc = Recyclable

Irrespective of cultivars, mean value for farm gate budgeting indicated that >50% of Fe and Mn went out and rest can be recycled by the cumin, whereas >50% Cu and Zn can be recycled at the farm and rest amount went out from the farm (Table 4). This might be the fact that cumin seeds have more iron content and accumulation in seed and obviously went it out from the farm as a consumable part. However, highest amount of Cu could be recycled by the cumin cultivars. This is because of higher content and uptake of Cu in stover.

Among the cultivars, highest Fe, Zn, Mn and Cu exported out by the cultivars GC-4, GC-2, GC-3 and GC-4, respectively, as these cultivars have more content and uptake of these nutrients in their seed. However, highest Fe, Zn, Mn and Cu could be recycled by the genotype/ cultivars AC-01-3, GC-3, GC-2 and AC-167, respectively. This indicates that these cultivars have more content and accumulation of these nutrients in their vegetative part resultant more of recyclable micronutrients. Surendran *et al* (19) carried out the nutrient budgeting at micro (plot/ field) and meso (farm) level via nutrient mining and enrichment using NUTrient MONitoring (NUTMON) model. They revealed that nutrient balance (inflow and outflow) in Coimbatore district of Tamil Nadu was negative for farm gate budgeting, either application of manures or chemical fertilizers leading to soil fatigue. Therefore, nutrient budgeting and integrated use of fertilizers and manures is essential for soil health and sustainability in crop production.

Conclusions

Highest uptake of N, P, S and micronutrients was in GC-4 and K was in GC-2 as compared to other cultivars. Cumin requires highest amount of N and Fe among the macro and micronutrients, respectively. Approximate requirement of N, P, K and S by cumin was 23.8, 5.6, 18.3 and 1.7 kg ha^{-1} respectively, whereas Fe, Zn, Mn and Cu were 418.2, 36.3, 92.9, and 20.8 g ha^{-1}, respectively. About 64% S, 62% Cu, 54.0% P & Zn, 52.0 % K, 49.0% N & Mn and 43.0% Fe can be recycled and rest of the amount went out from the farm gate.

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