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EFFECTS OF NITROGEN, PHOSPHORUS, POTASSIUM AND SULPHUR ON QUALITY SEED PRODUCTION IN CORIANDER

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ABSTRACT

A field experiment was carried out at Gazipur during the *rabi* season of 2009-10 to find out the contribution of macro fertilizers (N, P, K and S) along with cow dung on the yield of coriander (BARI dhania 1) (*Coriandrum sativum*) and to evaluate the economic return of coriander. The experiment consisted of four of each N levels (0, 40, 80 & 120 kg ha^{-1}), P levels (0, 15, 30 & 45 kg ha^{-1}), K levels (0, 25, 50 & 75 kg ha^{-1}) and S levels (0, 10, 15 & 20 kg ha^{-1}) in addition with cowdung (at 5 $tha^{-}$and 10tha^{-1}. The experiment was set up a randomized complete block design with three replications. The results showed that the different treatments significantly influenced seed and straw yields of coriander. All treatments combination exerted positive effect on the growth parameters (umbels $plant^{-1}$, numbers of umbellet $plant^{-1}$ and 1000-seed weight) and yield of coriander. The treatment T_3($N_{80}P_{30}K_{50}S_{15}$ kg ha^{-1}) gave the highest seed yield (1383 kg ha^{-1}). The seed yield increased 58% over absolute control. The highest agronomic efficiencies of N, P, K and S were found to be 9.98, 15.13, 5.12 and 11.6 at 40 kg N, 15 kg P, 50 kg K and 15 kg S, respectively. A combination of macronutrients, 80 kg N, 30 kg P, 50 kg K and 15 kg S $ha^{-1}$was found most profitable for seed production of coriander.

INTRODUCTION

Coriander (*Coriandrum sativum*) is an important spice crop grown mainly in winter season in Bangladesh. Soil and winter climate of Bangladesh are suitable for coriander seed production. The average yield in Bangladesh is 0.5 t ha^{-1} where as the research yield is 1.5 tha^{-1} (SAIC, 2006). The import of coriander seeds by Bangladesh was 190 mt in 2008-09 (SAIC, 2011). One of the most important reasons for low yield is the application of imbalanced and improper fertilization. The requirement of fertilizer for any crop varies with the cultivars and soil types in agro-ecological zones (Mitra *et al.,* 1990). It was reported that the application of macronutrients (NPKS) markedly increased yield of coriander seed (Anon, 2008). Among different major plant nutrients, nitrogen is required in large amounts by plants because it is a constituent of macromolecules such as protein, encourage cell elongation and vegetative growth. The coriander absorbs most of phosphorous in early growth stages and increases seed yield (Gosh *et al.*, 1986). Potassium is responsible for chlorophyll formation which plays an important part in the strength of cells and encourages flower and fruit formation. There is a limited effect of K are observed in coriander seed production but a positive effect is observed when the fertilizer of NPK is used combined in coriander seed production. Tripathi *et al.* (2009) reported that the seed yield increased with the application of sulphur and potassium.

Research information regarding the suitable dose of NPKS for the satisfactory production of coriander in Bangladesh is very meager although some fertilizer based research has accomplished by scientists of BARI. Considering above facts, the present study was undertaken to assess the appropriate level of N, P, K and S for obtaining satisfactory yield of coriander seed and to evaluate the economic return of coriander.

MATERIALS AND METHODS

The study was conducted at Gazipur during the *rabi* season of 2009-10. The experimental area represents the Madhupur Tract under Agro Ecological Zone (AEZ) 28. The soil of experimental field was silty clay and acidic in nature (pH 5.84). The soil nutrient level of N (0.093%), P (9.78 ppm), S (13.7 ppm) and Zn (0.51 ppm) was low but medium in terms of K (0.18 meq/100 g soil) and B (0.31 ppm). The mean maximum and minimum temperatures during the growing season were 31.36^{o} and 11.58^{o}C, respectively. The total rainfall during that time was 16.87 mm and the day length was 10-12 hours. The experiment was laid out in randomized complete block design with tree replications. Seeds of BARI dhania 1(*Coriandrum sativum*) were collected from Spices Research Centre, Bangladesh Agricultural Research Institute (BARI). The experiment consisted of four of each N levels (0, 40, 80 & 120 kg ha^{-1}), P levels (0, 15, 30 & 45 kg ha^{-1}), K levels (0, 25, 50 & 75 kg ha^{-1}) and S levels (0, 10, 15 & 20 kg ha^{-1}). In addition, cow dung at 5 tha^{-1} and 10 tha^{-1} were applied as treatments with macro nutrients combination. There were 16 treatments used in this trial which are exhibited in Table 1. The experimental field was ploughed with the help of tractor drawn disc plough followed by power tiller and leveled prior to sowing seeds. After land preparation, half of nitrogen and all of phosphorus, potassium, sulphur and cowdung were applied in the form of urea, TSP, MoP and gypsum, respectively. The remaining nitrogen was applied at 30 days after sowing (DAS) of seeds as top dress followed by irrigation. The seeds treated by Provax were sown in line maintaining 30 cm row to row distance apart with 15 cm between hills at the rate of 10 kg ha^{-1}. The sowing was done on November 17, 2009 with slight watering just to supply sufficient moisture for proper germination. Optimum soil moisture was maintained through fine mashed nozzle according to the need of the field soil. Weeding cum thinning was done in installments during at 25 and 50 DAS. Mulching or soil loosing was done after irrigation. Sevin powder was sprayed around

the plot at initial stage to protect the seeds against ant. Malathion @ 1.5 ml L^{-1} was sprayed against aphid. The spray was done at an interval of 15 days up to 45 days before harvest. The crop was harvested when the fruits color changed from green to straw color (March 7, 2010). Seeds were separated by beating with sticks and cleaned by winnowing and dried properly up to 10% moisture of seed. Data on yield and yield attributes along with other parameters were collected and subjected to statistical analysis by DMRT (Gomez and Gomez, 1993). Optimum dose of nutrients and agronomic efficiency of the study were computed following formula. Economics was also calculated of this study.

Optimum dose of nutrients

The optimum doses of nitrogen, phosphorous, potassium and sulphur for maximum yield of the crop was calculated from simple ploynomial regression equation i.e. $Y = \alpha + \beta_1 X + \beta_2 X^2$ (Zaman *et al*., 1982). Here x is the independent variable (seed yield). The optimum dose of fertilizer for maximum yield was $X = -\beta_1 / 2\beta_2$

Agronomic efficiency (AE) (BARC, 2005)

$AE = (GY_{NA} – GY_{NO}) \div NR$

GY_{NA}= Grain yield ($kgha^{-1}$) with addition of nutrient

GY_{NO} = Grain yield ($kg\ ha^{-1}$) without addition of nutrient

NR = Rate of added nutrient ($kg\ ha^{-1}$)

Table 1. Treatment combinations of different levels of N P K and S

Treatments	Nutrients combination ($kg\ ha^{-1}$)			
	N	P	K	S
T_1	0	30	50	15
T_2	40	30	50	15
T_3	80	30	50	15
T_4	120	30	50	15
T_5	80	0	50	15
T_6	80	15	50	15
T_7	80	45	50	15
T_8	80	30	0	15
T_9	80	30	25	15
T_{10}	80	30	75	15
T_{11}	80	30	50	0
T_{12}	80	30	50	10
T_{13}	80	30	50	20
T_{14} (Control)	0	0	0	0
T_{15}	Cowdung @ 10 tha^{-1}			
T_{16}	Cowdung @5 tha^{-1} +RDF (70-30-60-15 NPKSkg ha^{-1})			

RESULTS AND DISCUSSION

Plant height

Plant height was found maximum (77.30 cm) in T_7 treatment and statistically similar to all treatments while control (T_{14}) produced the lowest (64.33 cm). Plant height increased linearly with increase N rates but it significantly increased up to 80 kg N ha^{-1} beyond of which it declined (Table 2). N at 80 kg ha^{-1} increased plant height 16.10 % over absolute control treatment. Plant height also increased significantly up to 45 kg P, 50 kg K and 15 kg S ha^{-1}. Vinay *et al.* (1999) reported that P application increased the plant height but the difference between 30 and 60 kg ha^{-1} was not always significant.

Primary branches plant^{-1}

The primary branches $plant^{-1}$ differed significantly with different fertilizer treatment (Table 2). The ranges of primary branches $plant^{-1}$ were 4.57 to 6.6. The maximum number of primary branches $plant^{-1}$ was recorded in treatment T_3 (6.67) which were closely followed by T_{12} (6.06). There was no significant difference among the treatments T_2, T_3, T_4, T_6, T_7, T_9, T_{11}, T_{12}, T_{15} and T_{16}. The minimum number (4.57) of primary branches plant was observed in absolute control treatment (T_{14}). Rahman (2000) reported that the ranges of primary branches $plant^{-1}$ were 6.50-8.02 depending on varieties. Channabasavanna *et al.* (2002) reported that the highest number of primary branches was obtained at 60 kg Nha^{-1}.

Secondary branches plant^{-1}

A significant difference in secondary branches was observed at different fertilizer treatments (Table 2). The ranges of secondary branches $plant^{-1}$ were 12.33 to 6.67. The maximum number of secondary branches $plant^{-1}$ (12.33) was recorded in T_3 treatment and minimum (6.67) was recorded in control treatment (T_{14}). Secondary branches $plant^{-1}$ increase linearly with increase of N fertilizer up to 80 kg N ha^{-1} beyond which it declined. Datta *et al.* (2008) obtained the highest secondary branches $plant^{-1}$ with the application of 60kg N ha^{-1}.

Umbels plant^{-1}

The effect of different treatments on umbels $plant^{-1}$ was found statistically significant. The highest umbels number (46) $plant^{-1}$ was recorded in T_3 (Table 2) and the lowest number of umbels $plant^{-1}$ (24) was noted at control treatment. The number of umbels $plant^{-1}$, the major yield contributing character was influenced by the varying levels of nitrogen fertilizer and a significant increase in number of umbels $plant^{-1}$ was observed with increasing rate of N fertilizer application up to 80 kg h^{-1} and beyond which the number of umbels $plant^{-1}$ decreased significantly. Moniruzzaman (2011) reported that $N_{80}P_{40}K_{40}S_{20}$ treatment produced the maximum number of umbels $plant^{-1}$ (31.55).

Umbellets plant^{-1}

Marked significant variation among the treatments was observed in respect of umbellets $plant^{-1}$ (Table 2). It ranged from 90 to 182 which were closely followed by T_4 (155). The lowest number of umbellets $plant^{-1}$ (90) was found in control treatment. The treatments T_1, T_5, T_7, T_8, T_9, T_{10}, T_{13}, T_{15} and T_{16} produced moderate number of umbellets $plant^{-1}$ ranged from 101 to 115 and no significant difference was observed among these treatments. Sharma and Israel (1991) reported that umbellets $plant^{-1}$ increased (not always significantly) with increasing rate of P and N.

1000-seed weight

Thousand seed weight varied significantly among the different fertilizer treatments and ranged from 9.60 to 13.47g. The maximum 1000-seed weight (Table 2) was recorded from T_3 (13.47g) treatment being closely followed by T_6 (13.40g) and T_7 (13.20g). The lowest value was obtained from T_{14} (control). The minimum 1000 seeds weight was obtained when phosphorous, potassium and sulphur were not applied at all. The maximum 1000 seed weight was obtained in $N_{80}P_{40}K_{40}S_{20}$ treatment by Moniruzzaman (2011).

Seeds plant^{-1}

The treatments showed significant differences in respect of number of seed plant^{-1} which ranged from 246 to 530 (Fig. 1). The maximum seeds plant^{-1} (530) was obtained from T_3 which were identical with T_4 (518) and T_{12} (484). The lowest seeds plant^{-1} was recorded in T_{14} (246). There was no significant difference in respect of seeds plant^{-1} were obtained by T_1, T_2, T_5, T_6, T_8, T_{10}, T_{15} and T_{16}. Seeds plant^{-1} significantly increased with increase in N up to 80 kg ha^{-1} beyond which it declined. The highest number of seeds plant^{-1} was recorded at each of 30 kg P, 50 kg K and 15 kg S ha^{-1} and the minimum seeds were obtained from no P, K and S. Channabasavanna *et al.* (2002) reported that application of N @ 60 kg ha^{-1} and P @ 60 kg ha^{-1} produced the maximum number of seeds plant^{-1}.

Seed yield

The impact of N, P, K and S application on coriander seed yield was significant (Fig. 2). The treatment T_3 gave the maximum seed yield (1383.90 kg ha^{-1}) which was statistically at par with T_{12} (1351.96 kg) and T_{13} (1330.62 kg). The seed yield increased 58% over absolute control. The highest seed yield in treatment T_3 is due to the combined positive effects of primary and secondary branches, umbels, seeds plant^{-1}, 1000 seed weight. The minimum seed yield (580.16 kg ha^{-1}) was noticed in control treatment. The seed yield increased significantly with the increase in N doses up to 80 kg ha^{-1} and further increase in nitrogen level (120 kg N ha^{-1}) has led to decrease significantly. It reveals from the data that application of N @ 80 kgha^{-1} along with the recommended doses of P (30), K (50) and S (15 kgha^{-1}) is the best combination to give the highest yield of coriander seed in Salna series soil. Malav & Yadav (1997) reported that application of 80 kg produced the highest seed yield of coriander. In case of P, seed yield increased significantly up to 30 kg h^{-1}. The seed yield increased with increased application of K and S up to 50 kg and 15 kg ha^{-1}, respectively. Garg *et al.* (2000) got 37% higher yield from the application of 90 kg N ha^{-1} and 50 kg P ha^{-1}. A significant difference was obtained between cowdung (T_{15}) and cowdung with recommended fertilizer treatment (T_{16}). The yield (930.63 kg ha^{-1}) of cowdung applying treatment (T_{15}) was lower than mix fertilizer (cowdung with recommended fertilizer) treatment (T_{16}). The yield increased 18% in treatment T_{16} over treatment T_{15}.

Table 2. Effect of N P K and S on yield related characters of coriander

Treatment	Plant height (cm)	No of primary branches plant^{-1}	No of secondary branches plant^{-1}	No of umbels plant^{-1}	No of umbellet plant^{-1}	TSW (g)
T_1 ($N_0P_{30}K_{50}S_{15}$)	70.33 ab	5.03bc	10.00ab	35bc	101de	12.10b-e
T_2 ($N_{40}P_{30}K_{50}S_{15}$)	72.0ab	5.53abc	10.67ab	37bc	125bcd	12.93abc
T_3 ($N_{80}P_{30}K_{50}S_{15}$)	75.0a	6.67a	12.33a	46a	182a	13.47a
T_4 ($N_{120}P_{30}K_{50}S_{15}$)	74.67a	5.26abc	8.67bc	41ab	155ab	12.53a-d
T_5 ($N_{80}P_0K_{50}S_{15}$)	72.67ab	5.00bc	10.33ab	35bc	110de	11.33e
T_6 ($N_{80}P_{15}K_{50}S_{15}$)	76.67a	5.46abc	11.67ab	36bc	130bcd	13.40a
T_7 ($N_{80}P_{45}K_{50}S_{15}$)	77.33a	5.27abc	11.00ab	39ab	115cde	13.20ab
T_8 ($N_{80}P_{30}K_0S_{15}$)	74.67a	5.06bc	8.66 bc	35bc	102de	1.93cde
T_9 ($N_{80}P_{30}K_{25}S_{15}$)	71.67ab	5.60abc	9.67 ab	40ab	105de	12.40a-d
T_{10} ($N_{80}P_{30}K_{75}S_{15}$)	69.00ab	5.12bc	11.00 ab	35bc	107de	12.53b-e
T_{11} ($N_{80}P_{30}K_{50}S_0$)	73.00ab	5.30abc	9.33 abc	37bc	119b-e	11.63de
T_{12} ($N_{80}P_{30}K_{50}S_{10}$)	69.33ab	6.06ab	11.00 ab	38ab	146bc	13.07ab
T_{13} ($N_{80}P_{30}K_{50}S_{20}$)	69.67ab	5.15bc	10.67 ab	28cd	102de	12.93abc
T_{14} ($N_oP_0K_0S_0$)	64.33b	4.57c	6.67c	24d	90e	9.60f
T_{15} (Cow dung)	70.66ab	5.66abc	11.67 ab	36bc	106de	12.67a-d
T_{16} (Cow dung + RFD)	73.67a	5.33abc	9.67ab	37bc	109de	12.80abc
CV (%)	6.78	13.37	15.15	13.27	14.86	3.89

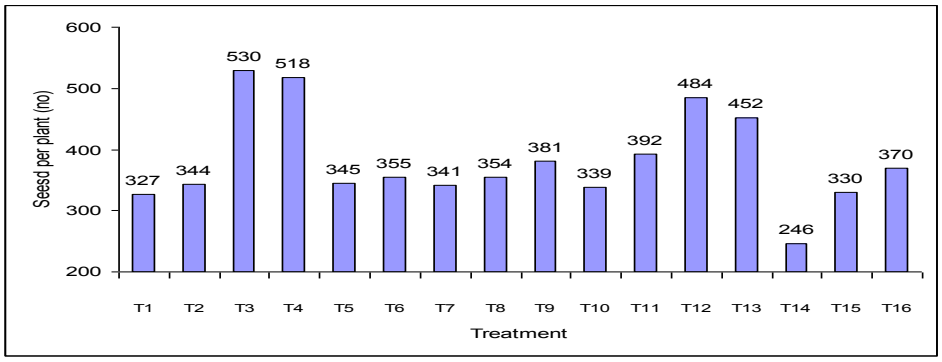

Figure 1. Effect of N P K and S on seeds per plant in coriander

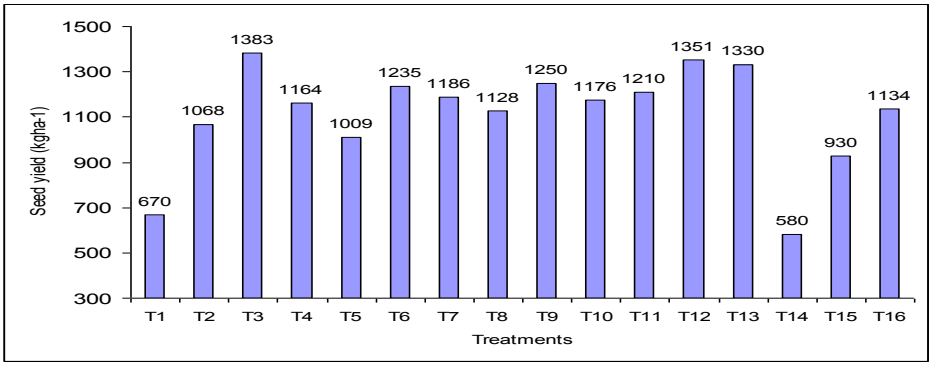

Figure 2. Effect of N P K and S on seed yield in coriander

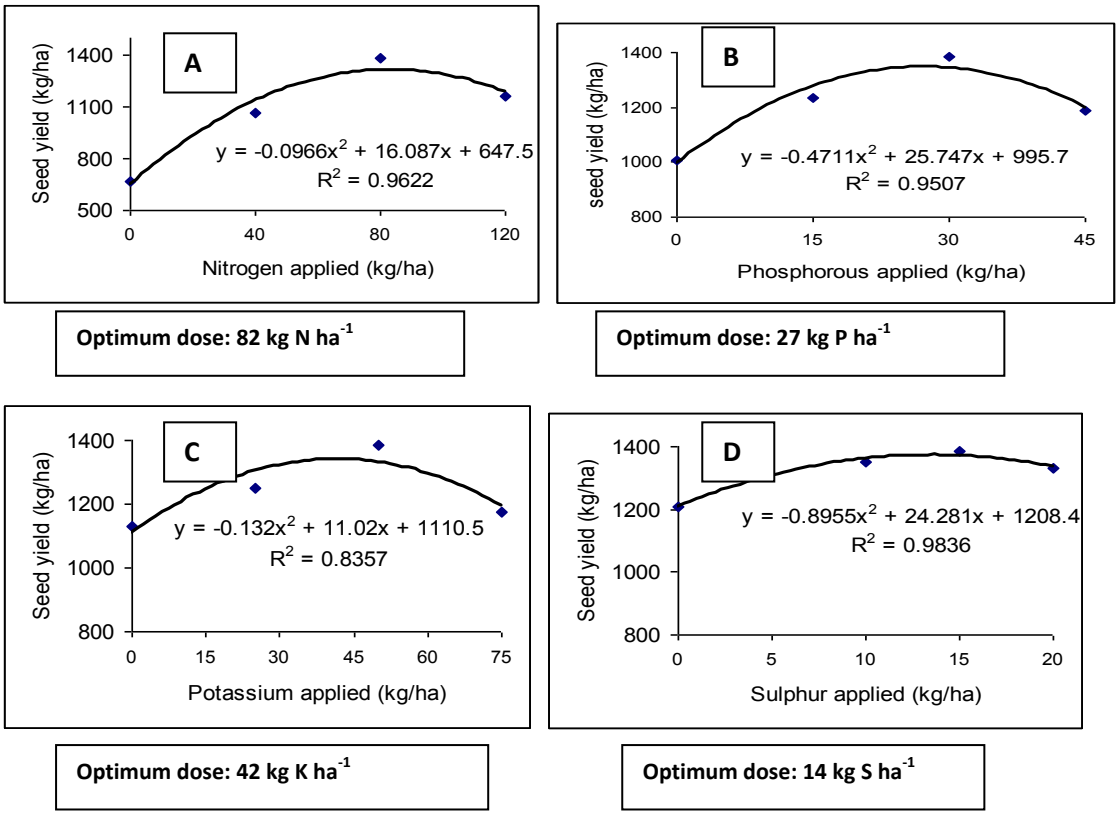

Figure 3. Response of seed yield of coriander to nitrogen (A), Phosphorus (B), Potassium (C) and Sulphur (D) fertilization

Stover yield and Harvest index

The stover yield varied significantly with different fertilizer treatments (Table 3). The treatment T_{13} produced the maximum stover yield (1463.25 kgha^{-1}) which was statistically at par with T_{12} (1456.91 kgha^{-1}) and closely followed the T_3 treatment also (1409.53 kgha^{-1}). The minimum value was exhibited in the control treatment (890.50 kg ha^{-1}). The different nutrient treatments influenced harvest index (HI) significantly (Table 3). The highest HI was recorded from T_3 treatment (50.08 %) which was closely followed by T_2, T_4, T_6 and T_{12} treatments. Harvest index significantly increased up to 80 kg N, 30 kg P and 50 kg K ha^{-1}. Harvest index increased up to 15 kg S ha^{-1} beyond which it declined. The lowest HI was observed in control treatment (39.46 %).Harvest index was higher in T_{16} treatment (46.20 %) than T_{15} (43.05 %).

Table 3. Effect of N P K and S on stover yield and harvest index

Treatment	Stover yield (kg ha^{-1})	HI (%)
T_1 ($N_0P_{30}K_{50}S_{15}$)	1089.28d	44.68bcd
T_2 ($N_{40}P_{30}K_{50}S_{15}$)	1151.95cd	48.12ab
T_3 ($N_{80}P_{30}K_{50}S_{15}$)	1409.53ab	50.08a
T_4 ($N_{120}P_{30}K_{50}S_{15}$)	1266.15a-d	47.88ab
T_5 ($N_{80}P_0K_{50}S_{15}$)	1328.96abc	43.16cd
T_6 ($N_{80}P_{15}K_{50}S_{15}$)	1300.95a-d	48.36ab
T_7 ($N_{80}P_{45}K_{50}S_{15}$)	1300.72a-d	47.59abc
T_8 ($N_{80}P_{30}K_0S_{15}$)	1360.91abc	44.46bcd
T_9 ($N_{80}P_{30}K_{25}S_{15}$)	1377.62abc	47.58abc
T_{10} ($N_{80}P_{30}K_{75}S_{15}$)	1170.31cd	46.32a-d
T_{11} ($N_{80}P_{30}K_{50}S_0$)	1366.93abc	46.75a-d
T_{12} ($N_{80}P_{30}K_{50}S_{10}$)	1456.91a	49.21a
T_{13} ($N_{80}P_{30}K_{50}S_{20}$)	1463.25a	47.38abc
T_{14} ($N_oP_0K_0S_0$)	890.50e	39.46e
T_{15} (Cow dung 10 t ha^{-1})	1228.65bcd	43.05d
T_{16} (Cowdung 5t ha^{-1} + $N_{70}P_{30}K_{60}S_{15}$)	1302.73a-d	46.20a-d
CV (%)	9.02	4.57

Response equation

Regression analysis was done to quantify the relationship of applied N, P, K and S with seed yield (kgha^{-1}) of coriander. A quadratic relationship with seed yield was observed in N, P, K and S (Figure 3). The estimated relationship reveals that seed yield would be increased with the application of N, P, K and S up to 82 kg N, 30 kg P, 50 kg K and 15 kg S ha^{-1} and beyond of these rates, the yield may be declined. From the regression equations (y = -0.0966x^2 + 16.087x + 647.5, y = -0.4711x^2 + 25.747x + 1062.2, y = -0.132x^2 + 11.02x + 1110.5 and y = -0.8955x^2 + 24.281x+1208.4 for N, P, K and S, respectively) the optimum doses of N, P, K and S were 83.27, 27.33, 41.74 and 13.56 k ha^{-1}. Bhati (1988a) obtained a quadratic response of seed yield with different doses of nitrogen (-.-0.000194x^2 + 0.03983x + 5.1351) and the economic optimum dose calculated from this equation was 84.36 kgha^{-1}. Overseas literature has reported that yield responses to P fertilizer will vary according to the level of avail P in the soil prior to sowing. Soils low in potassium will benefit from application of the K fertilizer up to 50kg K ha^{-1}.

Agronomic efficiency

The highest agronomic efficiencies (AE) of N, P, K and S were found to be 9.98, 15.13, 5.12 and 11.6 at 40 kg N, 15 kg P, 50 kg K and 15 kg S, respectively (Figure 4). The N efficiency increased up to 40 kg N ha^{-1} beyond which it declined. The application of 15 kg P ha^{-1} provided the highest agronomic efficiency. The highest AE was found in 50 kg K and 15 kg S ha^{-1} then beyond it declined. The results have similarity with Channabasavanna (2002) findings who reported that the highest agronomic efficiency was found in 40 kg N and 8.8 kg P ha^{-1}.

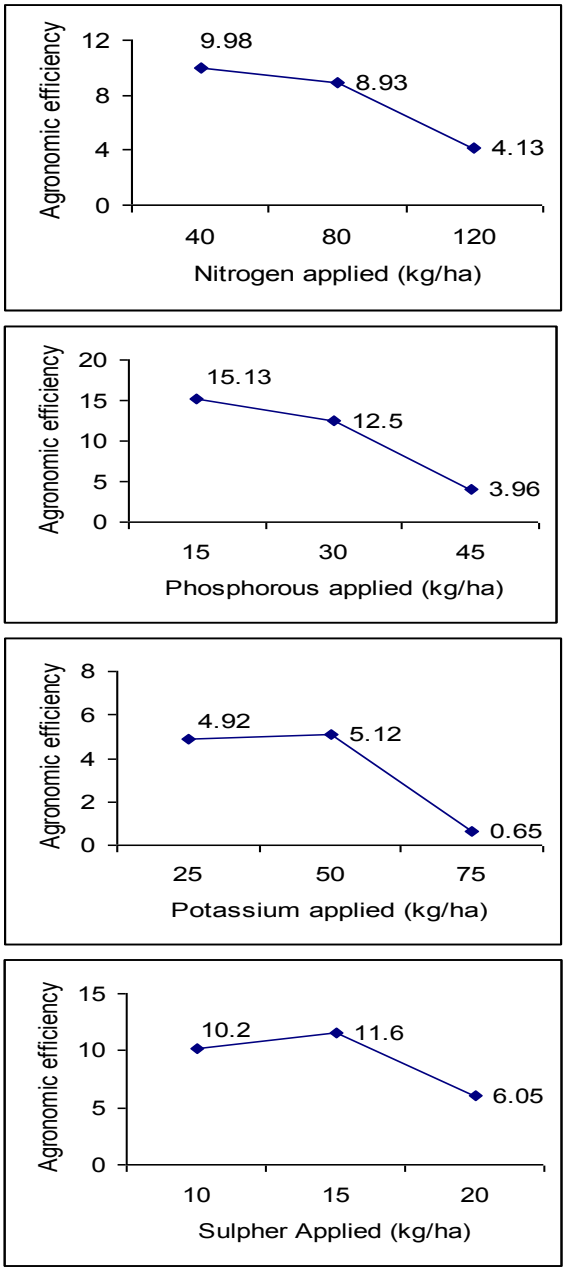

Figure 4. Agronomic efficiency as influenced by N, P, K and S

Table 4. Cost- return analysis for the different fertilizer treatments tested on coriander

Treatment	Seed yield (kg ha^{-1})	Gross return (Tk ha^{-1})	Cultivation cost (Tk ha^{-1})	Gross margin (Tk ha^{-1})	BCR
T_1 ($N_0P_{30}K_{50}S_{15}$)	670	33500	52420.00	(-)18920	0.64
T_2 ($N_{40}P_{30}K_{50}S_{15}$)	1069	53450	53050.00	400.00	1.00
T_3 ($N_{80}P_{30}K_{50}S_{15}$)	1384	69200	53700.00	15500.00	1.29
T_4 ($N_{120}P_{30}K_{50}S_{15}$)	1165	58250	54600.00	3650.00	1.07
T_5 ($N_{80}P_0K_{50}S_{15}$)	1009	50450	44650.00	5800.00	1.13
T_6 ($N_{80}P_{15}K_{50}S_{15}$)	1236	61800	49200.00	12600.00	1.25
T_7 ($N_{80}P_{45}K_{50}S_{15}$)	1187	59350	58710.00	640.00	1.01
T_8 ($N_{80}P_{30}K_0S_{15}$)	1128	56400	48050.00	8350.00	1.17
T_9 ($N_{80}P_{30}K_{25}S_{15}$)	1251	62550	50800.00	13750.00	1.23
T_{10} ($N_{80}P_{30}K_{75}S_{15}$)	1177	58850	56410.00	2390.00	1.04
T_{11} ($N_{80}P_{30}K_{50}S_0$)	1210	60500	53220.00	7280.00	1.14
T_{12} ($N_{80}P_{30}K_{50}S_{10}$)	1352	67600	53560.00	14040.00	1.26
T_{13} ($N_{80}P_{30}K_{50}S_{20}$)	1331	66550	53895.00	12655.00	1.23
T_{14} ($N_0P_0K_0S_0$)	580	29000	38540.00	(-)9540.00	0.75
T_{15} (Cow dung)	930	46500	46200.00	300.00	1.00
T_{16} (Cow dung + RFD)	1135	56750	59370.00	(-)2620.00	0.96

Price of product: Tk. 50.00 kg^{-1} (Seed), Tk. 7.00 kg^{-1} (Urea) , Tk.60.00 kg^{-1} (TSP), Tk. 56.00 kg^{-1}(MP), Tk.6.00 kg^{-1} (Gypsum) & Tk. 0.70 kg^{-1} (cowdung)

Economics

The cost-return analysis indicated that the maximum gross return (Tk. 69200.00 ha^{-1}) and gross margin (Tk.15500.00 ha^{-1}) were recorded in T_3 treatment (Table 4). The moderate gross margin was recorded from T_6, T_9, T_{12} and T_{13}. The treatment T_3 gave the highest BCR of 1.29.

CONCLUSION

It was observed that the treatment T_3 produced the maximum primary branches plant^{-1} (6.67), secondary branches plant^{-1} (12.33), umbels plant^{-1} (46), umbellets plant^{-1} (182), seeds plant^{-1} (530), 1000 seed-weight (13.47g), seed yield (1383.90 kg ha^{-1}), stover yield (1409.53 kg ha^{-1}) and harvest index (50.08 %). The seed yield of coriander exhibited the highest seed yield increase of 51.59, 27.1, 18.5 and 14.38 % over control at 80, 30, 50 and 15 kg ha^{-1} of N, P, K and S, respectively. Applied N, P, K and S showed a quadratic relationship with seed yield. From the regression equations it came up to be the optimum doses of N, P, K and S as 82, 27, 42 and 14 kg ha^{-1} respectively. The agronomic efficiencies of N, P, K and S were found the highest 9.98, 15.13, 5.12 and 11.6 at 40 kg N, 15 kg P, 50 kg K and 15 kg S, respectively beyond which it declined. The cost-return analysis of fertilizer use indicated that the maximum gross return (Tk. 69200.00) and gross margin (Tk. 15500.00) were found in T_3 treatment. The maximum benefit-cost ratio (BCR) (1.29) was recorded from T_3 treatment. However, the best fertilizer combination was $N_{80}P_{30}K_{50}S_{15}$ kg ha^{-1}.

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