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Effect of Macronutrients Combination with Plant Spacing on the Growth and Yield of Black Cumin (*Nigella sativa* L.)

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

An experiment was conducted into the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka from October 2019 to March 2020 this study the effect of macronutrients combination and plant spacing on growth and yield of black cumin (*Nigella sativa* L.). Black cumin variety BARI Kalozira-1 was used as planting material in this study. The experiment consisted of two factors: Factor-A: macro nutrient combinations (4 levels): T_1= $N_0P_0K_0$ kg ha^{-1} (control), T_2= $N_{90}P_{50}K_{40}$ kg ha^{-1}, T_3= $N_{135}P_{75}K_{60}$ kg ha^{-1}; Factor-B: plant spacing (3 levels): S_1= 20 cm × 10 cm, S_2= 20 cm × 15 cm and S_3= 20 cm × 20 cm. The experiment was laid out in a randomized complete block design with factorial with three replications. Data on different growth, yield and yield contributing parameter of black cumin were recorded and significant variation was observed from different treatments. In case of nutrient combinations, the tallest plant (54.86 cm) was observed from T_3 ($N_{135}P_{75}K_{60}$ kg ha^{-1}) treatment. The maximum primary branch plant^{-1} (8.62) and secondary branch plant^{-1} (12.18), flower plant^{-1} (22.20), capsules plant^{-1} (19.69) and 1000 seed weight (2.99 g) was observed from T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment. The highest seed yield ha^{-1} (1.18 t) was observed from T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment. In case of plant spacing the tallest plant (48.34 cm) was observed from S_1 (20

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cm × 10 cm) treatment. The maximum primary branch plant^{-1} (7.80) and secondary branch plant^{-1} (11.23) flower plant^{-1} (20.26), capsules plant^{-1} (18.81), 1000 seed weight (2.99 g) were observed from S_3 (20 cm × 20 cm) treatment. The highest seed yield ha^{-1} (1.09 t) was recorded from S_1 (20 cm × 10 cm) treatment. It can be concluded that, sowing of black cumin providing 90 kg N, 50 kg P and 40 kg K nutrient combination with 20 cm × 10 cm plant spacing was recorded to be more suitable practice for getting higher amount and quality of seed yield of black cumin.

Keywords: Black cumin; growth; macronutrients; plant spacing; yield.

1. INTRODUCTION

Black cumin (*Nigella sativa* L.) is well known as a spice crop in Bangladesh as well as in the world. It is commonly known as 'Kalozira' belongs to family Ranunculaceae and is cultivated in the winter season. It is believed to have originated in southeast Asia. It is widely cultivated in Southwest Asia, South Europe, Syria, Egypt, Pakistan, India, Iran, Japan, China and Turkey [1].In Bangladesh, it is grown well in Faridpur, Sariatpur, Madaripur, Pabna, Sirajganj, Jessore, Kusthtia and Natore districts. The flowers are delicate, and usually colored pale blue and white with 5 to 10 petals. The fruit is a large and inflated capsule composed of 3 to 7 united follicles, each containing throughout Black cumin is numerous seeds. The seed is used as a spice [2]. Black Cumin has a long history of use as food flavors, perfumes and medicinal values. Essential oil has been used for bringing smell to some medicines, for sterilizing of surgical operation fiber, for producing of some veterinary and agricultural medicines and plastic [3]. Proximate analysis of black cumin seeds showed a composition of 20.85% protein, 38.20% fat, 4.64% moisture, 4.37% ash, 7.94% crude fibre and 31.94% total carbohydrates; Potassium, phosphorus, sodium and iron were the predominant elements present [4]. The seed contain 30-35 % of oil which has several uses for pharmaceutical and food industries [5]. The medicinal value of the spice is immense and numerous workers appreciated its unique, varied and powerful pharmacological traits. The popularity of the plant was highly enhanced by the ideological belief in the herb as a cure for multiple diseases likes anti-tumour, anti-diabetic, cardioprotective, gastroprotective, antibacterial and antifungal activities were immensely appreciated. On Bangladesh black cumin was cultivated on 31 hectares of land and average yield 0.8-1.0 ton per hectares [6].

Fertilizer application to the plant greatly effects their growth, production plant constituents. Nitrogen (N) has the great effect on plant physiology and is probably the most important limiting nutrient for crop growth. Nitrogen strongly stimulates growth expansion of the plant canopy, yield and yield contributing characters and gross yield. Availability of nitrogen is most important for growing plants as it is a major and indispensable constituent of protein and nucleic acid molecules [7]. An adequate supply of nitrogen is associated with vigorous vegetative growth and more efficient use of available inputs finally lead to higher productivity. Phosphorus (P) is essential for the root development and more stem strength. It improves flower formation and makes seed production more uniform. It also improves seed quality and resistant to plant disease. The early supply of phosphorous to the crop is influenced by soil phosphorous and phosphorous application affect phosphorous phyto availability and root growth. Roots absorb phosphorous ions from the soil solution [8]. Potassium (K) fertilizer is another essential component to reduce the severity of disease of black cumin plants. Application of K ha along with N ha^{-1} decreased plant death due to disease and also increased yield in black cumin [9].

Plant spacing plays an important role in growth and yield. Optimum plant spacing ensures the plant to grow properly with their aerial and underground parts by utilizing more sunlight and soil nutrients [10]. High plant spacing make difficult for various intercultural operations. In a densely populated crop, the interplant competition is very high for essential nutrients, light and air, which usually results in mutual shading, lodging and thus favors more vegetative growth than grain yield. Black cumin lacks research recommendations on optimum plant density and row spacing that could lead to the poor yield of the crop. Hence, it is vital to identify the suitable seed rates and row spacing for black cumin production. Therefore, this study was initiated with the objective of finding out the optimum seed rate and inter- row spacing for better growth and yield attributes of black cumin.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Framework

The experiment was carried out into Horticultural Farm in Sher-e-Bangla Agricultural University, Dhaka-1207, Bangladesh. It is located at 23^0 41' N latitude and 90^0 22' E longitude at an altitude of 8.6 meters above the sea level. The land belongs to Agro-ecological zone of Modhupur Tract, AEZ-28. The selected land was medium high land with adequate irrigation facilities. The soil of the experimental site was sandy loam in texture having pH 5.47 - 5.63. Organic matter content was very low (0.83).

2.2 Seed

In this experiment black cumin variety of BARI Kalozira-1 was used as a planting material. BARI Kalozira-1 was developed by Bangladesh Agricultural Research Institute (BARI) in 2009. The seed was collected from the Regional Spice Research Centre, BARI, Joydebpur, Gazipur.

2.3 Treatments

The experiment consisted of two factor as: Factor A: Fertilizer (4 levels) $T_0 = N_0P_0K_0$ kg ha^{-1} (control), $T_1 = N_{45}P_{25}K_{20}$ kg ha^{-1}, $T_2 = N_{90}P_{50}K_{40}$ kg ha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kg ha^{-1} and Factor B: spacing (3 levels) S_1 = 20 cm×10 cm, S_2 = 20 cm×15 cm and S_3 = 20 cm×20 cm. The two factorial experiment was laid out in Randomized Complete Block Design (RCBD) with three replications to minimize the soil heterogeneous effects. The experiment was divided into 3 blocks and consisted of 36 plots. Each unit plot in from of raised bed was 1.44 m^2 (1.2m x 1.2m) in size. Totally there were 36 unit plots in experiment and required 51.84 m^2 land. Row to row distance was 20 cm and plant to plant distance at S_1 S_2 S_3 plot were 10 cm, 15 cm and 20 cm respectively. The treatments were randomly assigned to each of the block. Each unit plot had 6 rows and each with 6, 9 and 12 plants.

2.4 Fertilizer Management

Following doses of manures and fertilizers were recommended for the black cumin production.

Manure and Fertilizer		Dose
Cow dung		10 t/ha
Kitchen compost		5 t/ha
N	T_1	45 kg/ha
	T_2	90 kg/ha
	T_3	135 kg/ha
P_2O_5	T_1	25 kg/ha
	T_2	50 kg/ha
	T_3	75 kg/ha
K_2O	T_1	20 kg/ha
	T_2	40 kg/ha
	T_3	60 kg/ha
Gypsum		112 kg/ha
Boron		24 kg/ha

The above-mentioned doses of fertilizers were converted into manure and fertilizer mixed per treatment of the experiment and supplied by each type of manure and fertilizer except control. After conversion the dose of each manure used in the experiment was as bellow.

Each manure used in the experiment

Treatments	Cowdung (kg/ha)	Kitchen compost (kg/ha)	Urea (g/ha)	TSP (g/ha)	MOP (g/ha)	Gypsum (g/ha)	Boron (g/ha)
T_0	1.44	0.72	-	-	-	16.13	3.5
T_1	1.44	0.72	14.11	18	5.76	16.13	3.5
T_2	1.44	0.72	28.22	36	11.52	16.13	3.5
T_3	1.44	0.72	42.19	54	17.28	16.13	3.5

Note: T_0 = Control, $T_1 = N_{45}P_{25}K_{20}$ kg ha^{-1}, $T_2 = N_{90}P_{50}K_{40}$ kg ha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kg ha^{-1}

The calculated amounts of cowdung, kitchen compost, triple super phosphate, muriate of potash, gypsum, boron and half of the urea were applied before seed sowing. Rest half of the Urea was applied in two equal splits at 25 and 50 days after seed sowing.

2.5 Data Analysis

The recorded data on different parameters were statistically analyzed using Statistic 10 software. The significance of the difference among the treatments means was estimated by the least significant difference test (LSD) at 5% level of probability.

3. RESULTS AND DISCUSSION

3.1 Plant Height (cm)

Different level of macro nutrients (N, P, K) had significant influence on plant height of black cumin at different growth stages (Fig. 1). At 135 DAS (Days after sowing), the highest plant height (54.86 cm) was obtained from T_3 ($N_{135kg}P_{75kg}K_{60kg}$) treatment. Similarly, the lowest plant height (32.89 cm) was recorded from the T_0 (control) treatment. Hence it may be inferred that the increase in plant height may be due to the favorable influence and balanced absorption of nutrients, increased role of photosynthesis, reduced transpiration and stimulation of root system, increase cell division, cell enlargement and metabolic processes. It is also observed that plant height increased with macronutrient doses [11,12]. Different spacing had significant variation on plant height of black cumin at different growth stages **(**Fig. 2**)**. Plant height increased with decreased plant spacing. At 135 DAS, the highest plant height (48.34 cm) was achieved from S_1 (20 cm × 10 cm) treatment. Again, the lowest plant height (45.72cm) was observed from S_3 (20 cm × 20 cm) treatment. The treatment S_1 was statistically identical to S_2 which gave plant height of 18.13 cm at 45 DAS. The variation in plant height as influenced by spacing was perhaps due to proper utilization of nutrient, moisture and light(Fig.2) [13] was observed that plant height was increased by decreasing plant spacing an antagonistic relationship was found between vegetative growth and plant spacing [14] reported the smallest inter-row spacing (20 cm) produced the highest average plant heights while the lowest values were obtained at the largest inter-row spacing (40 cm) respectively. These findings on plant height were in accordance with [15,16,17]. Combined effect of different nutrients and spacing on plant height of black cumin was statistically significant at different days after sowing (DAS). At 135 DAS, the highest plant height (56.36 cm) was obtained from T_2S_1 ($N_{90}P_{50}K_{40}$ kg ha^{-1} and 20 cm × 10 cm) treatment combination, which was statistically similar to T_2S_2 ($N_{90}P_{50}K_{40}$ kg $ha^{-1}$and 20cm×15cm) treatment combination and the lowest plant height (32.20 cm) was observed from T_0S_3 (control and 20cm×20 cm) treatment combination which was statistically identical to T_2S_1.

3.2 Number of Primary and Secondary Branches Plant^{-1}

There was a significant variation due to effect of nutrient in the number of primary and secondary branches plant^{-1}. The maximum number of primary branches plant^{-1} (8.62) and secondary branches per plant (12.18) was observed at T_2 ($N_{90}P_{50}K_{40}$ kgha^{-1}) treatment while controlled treatment showed comparatively lower (5.50) and (8.60) number of primary and secondary branches per plant respectively (Table 2). The results of the present study indicated that optimum levels of macro nutrients combination might have induced better growing condition, perhaps due to supply of adequate plant nutrients which ultimately led to the production of more primary and secondary branches per plant [16,18]. The number of primary and secondary branch plant^{-1} of black cumin was influenced significantly under different level of fertilizer.

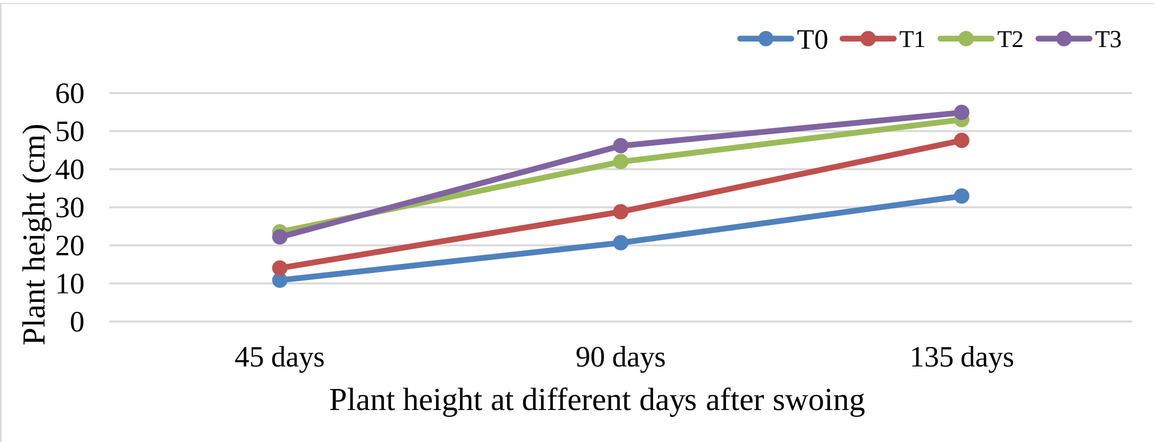

Fig. 1. Effect of nutrients combination on plant height of black cumin (*Nigella sativa* L.)
(LSD value= 0.4479, 1.1080 and 0.5814 at 45, 90 and 135 DAS respectively), Note: $T_0 = N_0P_0K_0$ kgha^{-1}(control), $T_1 = N_{45}P_{25}K_{20}$ kgha^{-1}, $T_2 = N_{90}P_{50}K_{40}$ kgha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kgha^{-1}

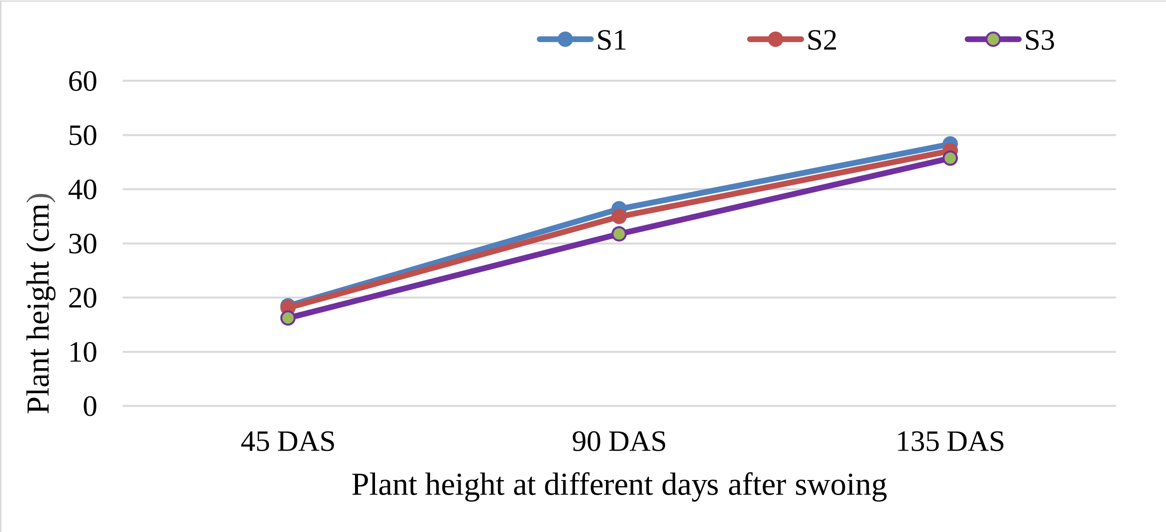

Fig. 2. Effect of plant spacing on plant height of black cumin (*Nigella sativa* L.)
(LSD value= 0.3879, 0.9596 and 0.5035 at 45, 90 and 135 DAS respectively) Note:S_1 = 20 cm × 10 cm, S_2 = 20 cm × 15 cm and S_3 = 20 cm × 20 cm

Table 1. Combined effect of nutrients combination and plant spacing on plant height at 45 DAS, 90 DAS and 135 DAS of black cumin (*Nigella sativa* L.)

Treatments	Plant height (cm)		
	45 DAS	90 DAS	135 DAS
T_0S_1	10.49 h	20.71 fg	33.87 g
T_0S_2	11.55 g	21.75 f	32.60 h
T_0S_3	10.30 h	19.42 g	32.20 h
T_1S_1	14.20 e	32.27 d	48.33 e
T_1S_2	14.33 e	27.47 e	47.67 e
T_1S_3	13.40 f	26.53 e	46.53 f
T_2S_1	25.27 a	50.27 a	56.36 a
T_2S_2	24.62 ab	48.96 a	55.63 ab
T_2S_3	20.57 d	39.13 c	52.60 c
T_3S_1	23.91 b	42.27 b	54.81 b
T_3S_2	22.00 c	41.67 b	52.53 cd
T_3S_3	20.60 d	41.87 b	51.53 d
LSD(0.05)	0.7758	1.9191	1.0070
CV%	2.60	3.30	1.26

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Note: $T_0 = N_0P_0K_0$ kgha^{-1}(control), $T_1 = N_{45}P_{25}K_{20}$ kgha^{-1}, T_2 = N-$_{90}P_{50}K_{40}$ kgha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kgha^{-1}and S_1 = 20 cm ×10 cm, S_2 = 20 cm × 15 cm, S_3 = 20 cm × 20 cm

Significant variation was found due to the effect of spacing on number of primary and secondary branches per plant. It was observed that the lowest number of primary and secondary branches per plant (7.09) and (10.35) was recorded from S_1 (20 cm × 10 cm) treatment and highest (7.80) and (11.23) from S_2 (20 cm × 20 cm) treatment respectively (Table 3). Generally lower number of plants was provided more nutrients compared to higher population with same nutrient status in the soil that was provided and caused more number of primary branches per plant from higher plant spacing. These findings are in agreement with those of [19]. [20] attributed the increments in vegetative characteristics to less competition among plants for the environmental conditions necessary for building up more metabolites and producing more lateral branches at wider spaces.

Number of primary and secondary branches per plant showed that significant variation among the treatments due to the combined effect of macronutrients and plant spacing. Highest primary and secondary branches per plant (8.80) and (12.47) was found from the T_2S_3 ($N_{90}P_{50}K_{40}$ kg $ha^{-1}$and 20cm × 20cm) treatment combination. On the other hand, lowest value for primary and secondary branches per plant (4.96) and (8.20) was recorded in T_0S_1 (control and 20cm × 10 cm) treatment combination (Table 4). Generally more nutrients and higher spacing plant get more food and space for vigorous growth and produce more primary branches compared to lower nutrients and spacing.

3.3 Number of Flowers and Capsules Per Plant

The number of flowers $plant^{-1}$and capsule $plant^{-1}$ was significantly affected by different levels of nutrient combinations (Fig. 3 and Table 2). Number of flowers and capsule $plant^{-1}$ increased with the increase level of nutrients. The highest number of flowers and capsule $plant^{-1}$ (22.20) and (19.81) was recorded atT_2($N_{90}P_{50}K_{40}$ $kgha^{-1}$)treatment. The lowest number of flowers $plant^{-1}$ was recorded from T_0 (control) treatment (17.56) and (16.17). From the results of the present study indicated that number of flowers $plant^{-1}$ increased with the increase in nutrient doses. These findings are in agreement with those of [12].

Significant variations were clearly evident in case of number of flowers $plant^{-1}$ and capsule $plant^{-1}$ with different plant spacing (Fig. 4 and Table 3). The highest number of flowers and capsule $plant^{-1}$ (20.26) and (18.81) resulted from S_3(20 cm × 20 cm) treatment and the lowest (19.90) and (17.62) was obtained from S_1(20 cm × 10 cm) treatment which was statistically identical (19.96) to S_2 (20 cm × 15 cm) treatment. From the results of the present study indicated that increase in plant density decreased number of flowers $plant^{-1}$.

Combined effect of different macronutrient and spacing was statistically significant in respect of number of flowers $plant^{-1}$ (Table 4). The highest number of flower and capsule $plant^{-1}$ (22.87) and (20.80) obtained from T_2S_3 ($N_{90}P_{50}K_{40}$ kg $ha^{-1}$and 20 cm × 20 cm) treatment combination. The lowest number of flower and capsule $plant^{-1}$ (17.20) and (15.33) obtained from T_0S_1 (control and 20 cm×10 cm) treatment combination respectivelywhich was statistically identical (17.35) to T_0S_2 (control and 20 cm×15 cm) treatment combination.

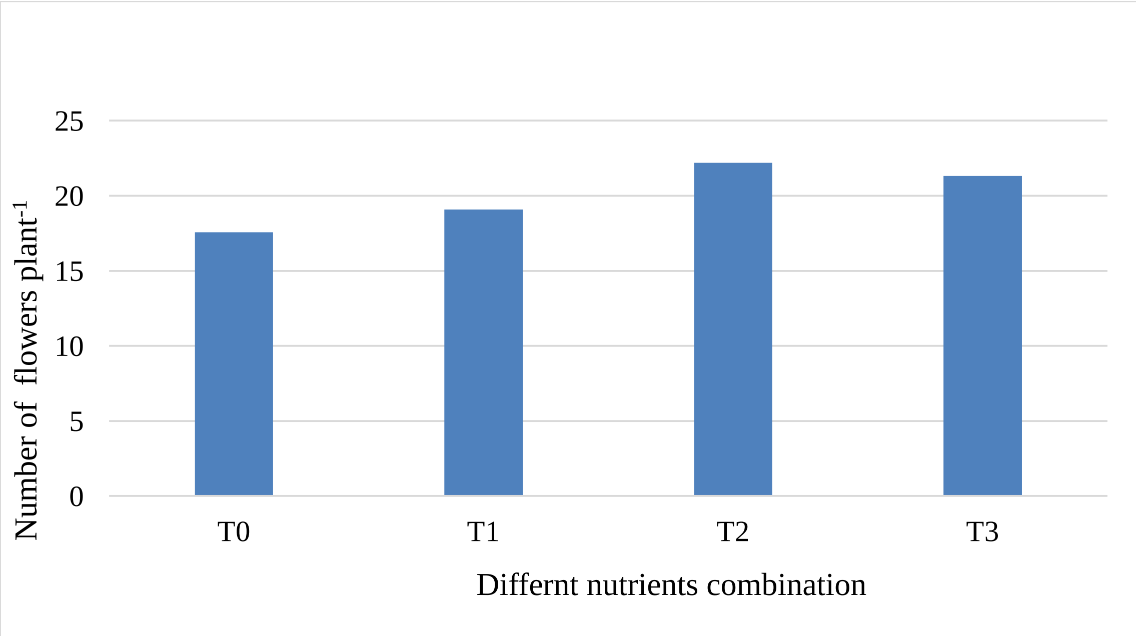

Fig. 3. Effect of nutrients combination on number of flowers $plant^{-1}$ of black cumin (*Nigella sativa* L.)

(LSD value= 0.2007)Note: $T_0 = N_0P_0K_0$ $kgha^{-1}$(control), $T_1 = N_{45}P_{25}K_{20}$ $kgha^{-1}$, $T_2 = N_{90}P_{50}K_{40}$ $kgha^{-1}$, T_3 = N-$_{135}P_{75}K_{60}$ $kgha^{-1}$

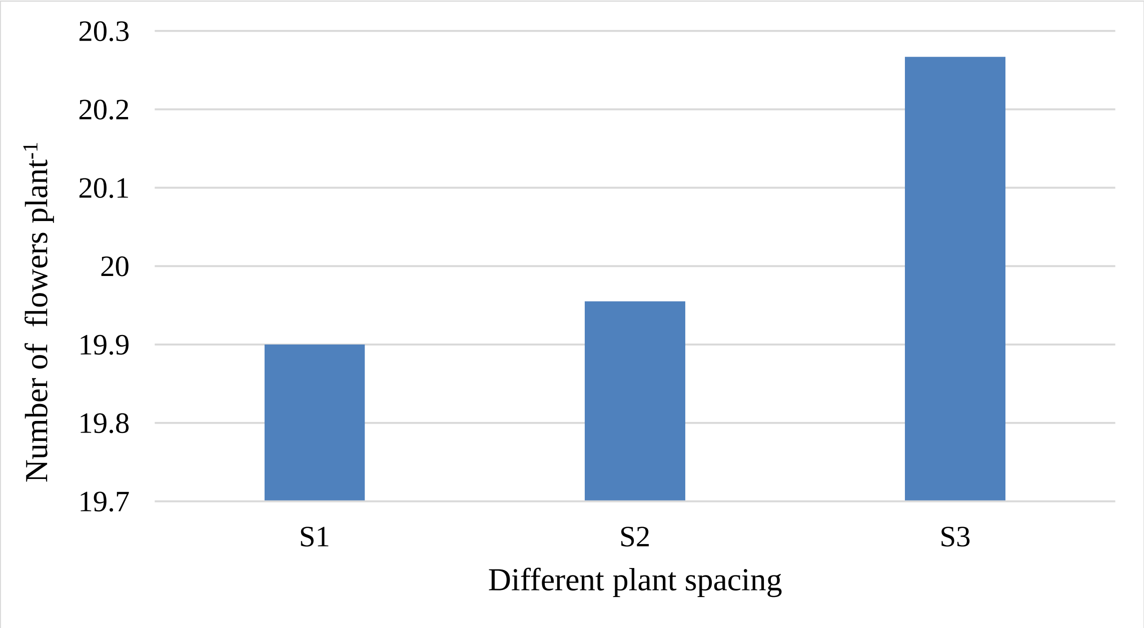

Fig. 4. Effect of plant spacing on number of flowers plant^{-1} of black cumin (*Nigella sativa* L.)
(LSD value= 0.1738) S_1 = 20 cm ×10 cm, S_2 = 20 cm × 15 cm, S_3 = 20 cm × 20 cm

Table 2. Effect of nutrients combination on number of primary branches plant^{-1}, secondary branches plant^{-1} and capsules plant^{-1} of black cumin (*Nigella sativa* L.)

Treatments	Number of Primary branches plant^{-1}	Number of Secondary branches plant^{-1}	Number of capsules plant^{-1}
T_0	5.50 d	8.60 d	16.17 c
T_1	7.42 c	10.98 c	17.04 b
T_2	8.62 a	12.18a	19.81 a
T_3	8.09 b	11.51 b	19.69 a
LSD(0.05)	0.2077	0.1622	0.2773
CV%	2.87	1.53	2.56

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Note: $T_0 = N_0P_0K_0$ kgha^{-1}(control), $T_1 = N_{45}P_{25}K_{20}$ kgha^{-1}, $T_2 = N_{90}P_{50}K_{40}$ kgha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kgha^{-1}

Table 3. Effect of plant spacing on number of primary branches plant^{-1}, secondary branches plant^{-1} and capsules plant^{-1} of black cumin (*Nigella sativa* L.)

Treatments	Number of Primary branches plant^{-1}	Number of Secondary branches plant^{-1}	Number of capsules plant^{-1}
S_1	7.09 c	10.35 c	17.62 c
S_2	7.34 b	10.87 b	18.10 b
S_3	7.80 a	11.23 a	18.81 a
LSD(0.05)	0.1799	0.1404	0.2402
CV%	2.87	1.53	2.56

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Note: S_1 = 20 cm ×10 cm, S_2 = 20 cm × 15 cm, S_3 = 20 cm × 20 cm

Table 4. Combined effect nutrients combination and plant spacing on primary branches plant^{-1}, secondary branches plant^{-1}, number of flowers plant^{-1}, number of capsules plant^{-1}of black cumin (*Nigella sativa* L.)

Treatments	Number of primary branches plant^{-1}	Number of secondary branches plant^{-1}	Number of flowers plant^{-1}	Number of capsules plant^{-1}
T_0S_1	4.96 g	8.20 h	17.20 g	15.33 f
T_0S_2	5.22 g	8.40 h	17.35 g	16.00 e
T_0S_3	6.33 f	9.20 g	18.13 f	17.19 d
T_1S_1	7.20 e	10.67 f	19.20 e	17.47 d
T_1S_2	7.67 d	11.07 e	18.87 e	16.27 e
T_1S_3	7.40 de	11.20 e	19.20 e	17.40 d
T_2S_1	8.47 abc	11.80 cd	21.53 c	18.22 c
T_2S_2	8.60 ab	12.29 ab	22.20 b	20.40 a
T_2S_3	8.80 a	12.47 a	22.87 a	20.80 a
T_3S_1	7.73 d	10.73 f	21.67 c	19.47 b
T_3S_2	8.13 c	11.73 d	21.40 c	19.74 b
T_3S_3	8.40 bc	12.06 bc	20.87 d	19.86 b
LSD(0.05)	0.3598	0.2809	0.3476	0.484
CV%	2.87	1.53	2.02	2.56

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability.

Note: $T_0 = N_0P_0K_0$ *kgha*$^{-1}$*(control),* $T_1 = N_{45}P_{25}K_{20}$ *kgha*$^{-1}$*,* $T_2 = N_{90}P_{50}K_{40}$ *kgha*$^{-1}$*,* $T_3 = N_{135}P_{75}K_{60}$ *kgha*$^{-1}$ *and* S_1 *= 20 cm ×10 cm,* S_2 *= 20 cm × 15 cm,* S_3 *= 20 cm × 20 cm*

3.4 1000 Seed Weight (g)

Different levels of NPK fertilizer had significant effect on 1000 seed weight of black cumin (Table 5). Application of macronutrients at different levels significantly increased the 1000 seed which produced maximum seed weight (2.99 g) at T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment where T_0 (control) treatment gave the lowest 1000 seed weight (2.80 g) [21] stated that there were no statistical differences among the different nitrogen doses in black cumin. In different studies, thousand seed weight of black cumin was reported as 3.50 g.

1000 seed weight of black cumin was significantly influenced by different level of spacing (Table 6). It was observed that higher spacing gave maximum yield. The maximum 1000 seed weight (2.96 g) was recorded from S_3 (20 cm × 20 cm) treatment where the lowest 1000 seed weight (2.82 g) was recorded from S_1 (20 cm × 10 cm) treatment.Similar findings were also obtained by [12,22].

Combined effect of different levels of macronutrient and spacing proved significant differences on 1000 seed weight of black cumin (Table 7). Results revealed that the highest 1000 seed weight (3.06 g) was obtained from T_2S_3 ($N_{90}P_{50}K_{40}$kg ha^{-1} with 20 cm × 20 cm) treatment combination which was statistically similar to T_2S_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1} and 20 cm×15 cm) treatment combination. The lowest 1000 seed weight (2.75 g) was recorded from T_0S_1 (control and 20 cm×10 cm) treatment combination which was statistically similar to T_0S_2 (control and 20 cm×15 cm) and T_1S_1 ($N_{45}P_{25}K_{20}$ kg ha^{-1} and 20 cm×10 cm) treatment combination. Rest of the treatment combination performed intermediate results in terms of 1000 seed weight compared to all other treatments [23,24] also found significant effect of fertilizer levels on thousand seed weight of black cumin.

3.5 Yield Per Plant (g)

Yield per plant was significantly influenced due to different levels of macronutrient (Figure 5). Yield was increased with increasing plant nutrients. Results showed that the maximum yield per plant (3.36 g) was recorded from T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment and the lowest yield of per plant (2.51 g) was recorded from T_0 (control)treatment. From the above results, it was noted that NPK when used the nutrients become available to plants and much seed formation was occurred. The available soil nutrients supported proper vegetative growth with more protoplasm in the cells in comparison to less available nutrient in black cumin. The results found from the findings of [25,26] were similar with the present study.

Yield plant^{-1} was significantly influenced by different level of spacing (Fig. 6). It was observed that higher spacing gave maximum yield. The maximum yield plant^{-1} (3.36 g) was recorded from S_3 (20 cm × 20 cm) treatment where the lowest yield plant^{-1} (2.51 g) was recorded from S_1 (20 cm × 10 cm) treatment. It might be due to the fact that in treatment S_3 (20 cm × 20 cm) treatment received adequate plant nutrients, no inter competition among plants, favorable growing atmosphere which contributed yield plant^{-1} (g). The result achieved from the present study was conformity with the findings of [27,22] who observed higher yield plant^{-1} from wider spacing.

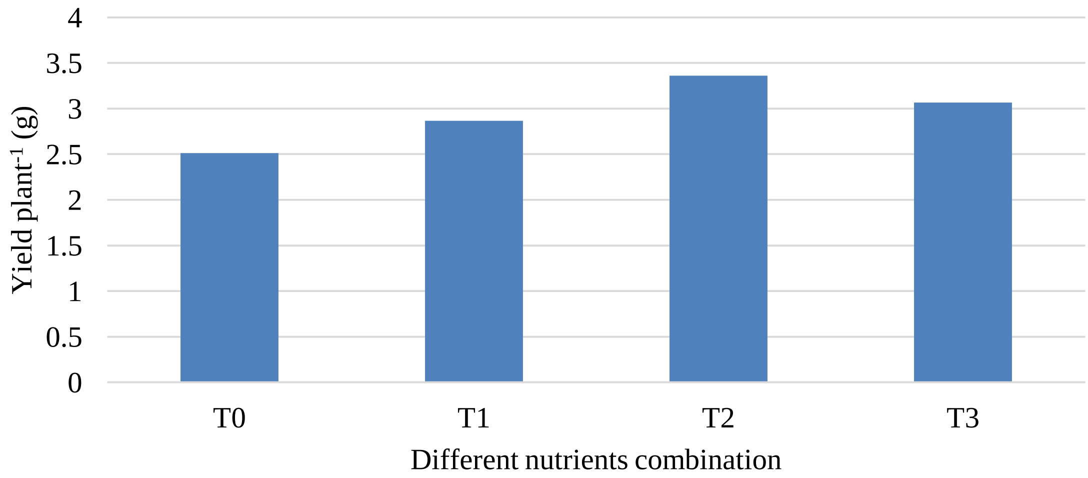

Fig. 5. Effect of nutrients combination on yield plant^{-1} of black cumin (*Nigella sativa* L.)
(LSD) value= 0.1211)Note: $T_0 = N_0P_0K_0$ kgha^{-1}(control), $T_1 = N_{45}P_{25}K_{20}$ kgha^{-1}, $T_2 = N_{90}P_{50}K_{40}$ kgha^{-1}, T_3 = N-$_{135}P_{75}K_{60}$ kgha^{-1}

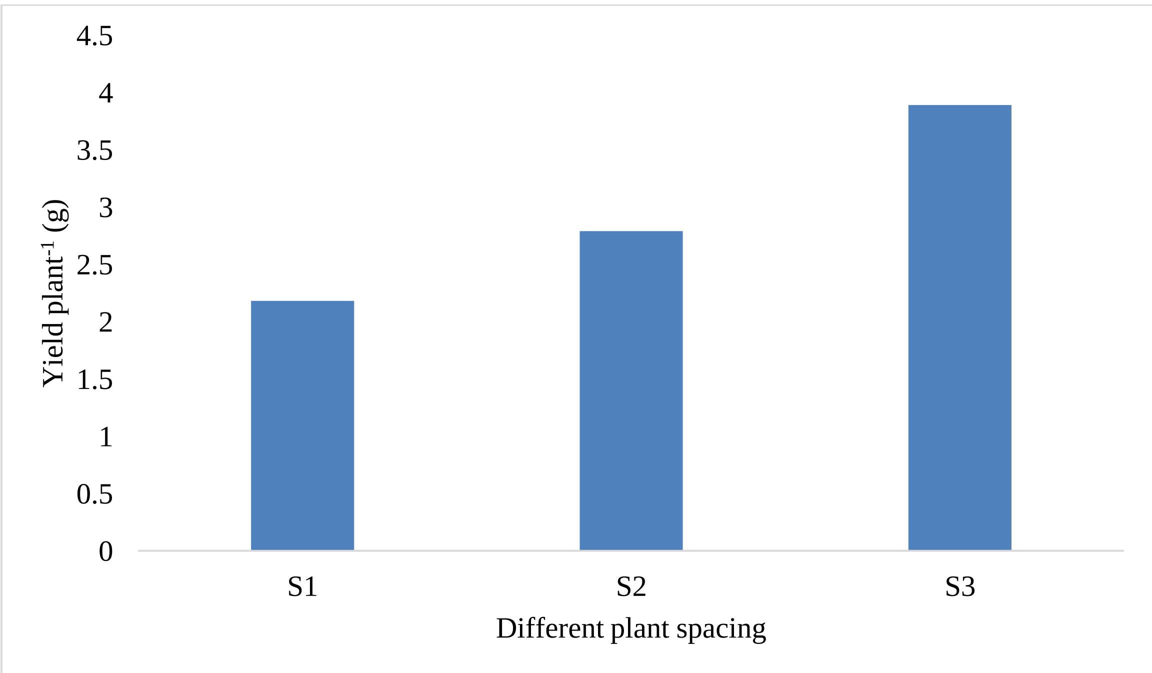

Fig. 6. Effect of plant spacing on yield plant^{-1} of black cumin (*Nigella sativa* L.)
(LSD value= 0.1049). Note:S_1 = 20 cm ×10 cm, S_2 = 20 cm × 15 cm, S_3 = 20 cm × 20 cm

Combined effect of different levels of macronutrient and spacing proved significant differences on yield plant^{-1} of black cumin (Table 7). Results revealed that the highest yield plant^{-1} (4.34 g) was obtained from T_2S_3 ($N_{90}P_{50}K_{40}$ kg ha^{-1} and 20 cm × 20 cm) treatment combination. The lowest yield plant^{-1} (1.87 g) was recorded from T_0S_1 (control and 20 cm × 10 cm) treatment combination. Rest of the treatment combination performed intermediate results in terms of yield plant^{-1} compared to all other treatments.

3.6 Yield per Plot (g) and ha (t)

Yield per plot of black cumin was significantly affected by different levels of macronutrient (Table 5). Higher application of plant nutrients gave higher seed yield per plot. Results specified that the highest yield per plot and ha of black cumin (170.40 g) and (1.18 t) was recorded from T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment where the lowest yield per plot and ha of black cumin (127.14 g) and (0.88 t) was recorded from T_0 (control) treatment. The results obtained from the present study were similar with the findings of [28,12].

Different levels of spacing had significant effect on yield per plot of black cumin (Table 6). It was found that the highest yield per plot of black cumin (156.66 g) and (1.09 t) was recorded from S_1 (20 cm × 10 cm) treatment where the lowest yield per plot of black cumin (140.04 g) and (0.97 t) was recorded from S_3 (20 cm × 20 cm) treatment. The obtained results represented that maximum yield contributing characters was best with higher spacing but in case of yield closer spacing gave maximum yield and this result might be due to cause of higher plant population from closer spacing [27] studied the effect of row spacing on seed yield and yield components of black cumin and found similar results on seed yield per plot with the present study.

Yield per plot of black cumin was significantly affected by combined effect of different levels of macronutrient and spacing (Table 7). It was observed that the highest yield per plot (178.32 g) and yield per ha (1.24 t) was obtained from T_2S_1 ($N_{90}P_{50}K_{40}$ kg ha^{-1} and 20 cm × 10 cm) treatment combination which is statistically identical to T_2S_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1} and 20 cm×15 cm) combination. Results also revealed that the lowest yield per plot of black cumin (118.68 g) and yield per ha (0.82 t) was recorded from T_0S_3 (control and 20 cm × 20 cm) treatment combination, which was statistically similar to T_0S_2 (control and 20 cm × 15 cm) treatment combination. The results obtained from all other treatment combination gave intermediate results compared to highest and lowest results. Higher number of plant population need higher amount of nutrients. Under the present study, closer spacing with higher nutrient doses gave the higher yield and this type of achievement might be due to higher plant population.

3.7 Dry Matter (g)

Significant influence was noted on dry matter affected by different macro nutrients (N, P, K) (Table 5). The highest dry matter at harvest (11.29 g) was obtained from the T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment where the lowest dry matter at harvest (7.90 g) was obtained from the T_0 (control) treatment. These findings are also supported by [29] dry matter weight plant^{-1} was increased gradually with the higher level of applied fertilizer.

Significant variations were clearly evident in case of dry matter with different plat spacing (Table 6). The highest dry matter resulted from S_3 (20 cm × 20 cm) treatment (18.81) and the lowest (17.62) was obtained from S_1 (20 cm × 10 cm) treatment. From the results of the present study indicated that increase in plant density dry matter.

Table 5. Effect of nutrients combination on 1000 seed weight, yield plot^{-1}, yield ha^{-1} and dry matter of black cumin (*Nigella sativa* L.)

Treatments	1000 seed weight (g)	Yield plot^{-1}(g)	Yield ha^{-1}(t)	Dry matter (g)
T_0	2.80 c	127.14 d	0.88 d	7.90 d
T_1	2.90 b	144.52 c	1.00 c	8.93 c
T_2	2.99 a	170.40 a	1.18 a	11.29 a
T_3	2.89 b	154.30 b	1.07 b	10.70 b
LSD(0.05)	0.0347	6.2480	0.0434	0.2528
CV%	0.91	4.29	4.29	2.66

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Note: $T_0 = N_0P_0K_0$ kgha^{-1}(control), $T_1 = N_{45}P_{25}K_{20}$ kgha^{-1}, $T_2 = N_{90}P_{50}K_{40}$ kgha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kgha^{-1}

Table 6. Effect of plant spacing on 1000 seed weight, yield plot^{-1}, yield ha^{-1}, and dry matter of black cumin (*Nigella sativa* L.)

Treatments	1000 seed weight (g)	Yield plot^{-1}(g)	Yield ha^{-1}(t)	Dry matter (g)
S_1	2.82 c	156.66 a	1.09 a	9.30 c
S_2	2.91 b	150.57 b	1.05 b	10.03 a
S_3	2.96 a	140.04 c	0.97 c	9.79 b
LSD(0.05)	0.0272	5.4109	0.0376	0.2189
CV%	0.91	4.29	4.29	2.66

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Note: S_1 = 20 cm ×10 cm, S_2 = 20 cm × 15 cm, S_3 = 20 cm × 20 cm, NS= Not significant

Table 7. Combined effect nutrients combination and plant spacing on 1000 seed weight, yield plant^{-1}, yield plot^{-1}, yield ha^{-1}, and dry matter of black cumin (*Nigella sativa* L.)

Treatments	1000 seed weight (g)	Yield per plant (g)	Yield per plot (g)	Yield per ha (t)	Dry matter (g)
T_0S_1	2.75 h	1.87 j	134.40 fg	0.93 fg	7.64 h
T_0S_2	2.81 fgh	2.38 gh	128.34 gh	0.89 gh	7.97 gh
T_0S_3	2.85 efg	3.30 d	118.68 h	0.82 h	8.08 g
T_1S_1	2.79 gh	2.12 i	152.40 bcd	1.06 bcd	8.553 f
T_1S_2	2.93 cd	2.66 ef	143.64 def	0.99 def	9.25 e
T_1S_3	2.98 bc	3.82 c	137.52 efg	0.96 efg	8.99 e
T_2S_1	2.90 cde	2.48 fg	178.32 a	1.24 a	10.14 d
T_2S_2	3.02 ab	3.27 d	176.76 a	1.23 a	12.13 a
T_2S_3	3.06 a	4.34 a	156.12 bc	1.08 bc	11.61 b
T_3S_1	2.84 efg	2.24 hi	161.52 b	1.12 b	10.85 c
T_3S_2	2.88 def	2.84 e	153.54 bcd	1.07 bcd	10.76 c
T_3S_3	2.96 bc	4.11 b	147.84 cde	1.03 cde	10.50cd
LSD(0.05)	0.0786	0.2097	10.822	0.0752	0.4379
CV%	0.91	4.20	4.29	4.29	2.66

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly by LSD at 0.05 levels of probability. Note: $T_0 = N_0P_0K_0$ kgha^{-1}(control), $T_1 = N_{45}P_{25}K_{20}$ kgha^{-1}, T_2 = N-$_{90}P_{50}K_{40}$ kgha^{-1}, $T_3 = N_{135}P_{75}K_{60}$ kgha^{-1} and S_1 = 20 cm ×10 cm, S_2 = 20 cm × 15 cm, S_3 = 20 cm × 20 cm. NS= Not significant

Combined effect of different levels of macronutrient and spacing proved significant differences on dry matter weight of black cumin (Table 7). Results revealed that the highest dry matter weight (12.13 g) was obtained from T_2S_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1} and 20 cm × 15 cm) treatment combination. The lowest dry matter weight (7.64 g) was recorded from T_0S_1 (control and 20 cm × 10 cm) treatment combination which was statistically similar to T_0S_2 treatment combination. Rest of the treatment combination performed intermediate results in terms of dry matter weight compared to all other treatments.

4. CONCLUSION

Considering the above result of this experiment; the following conclusion and recommendations can be drawn:

- In the experiment T_2 ($N_{90}P_{50}K_{40}$ kg ha^{-1}) treatment was more effective than without nutrient T_0 (control)
- The spacing S_3 (20 cm × 20 cm) gave higher seed yield per plant but the spacing S_1 (20 cm ×10 cm) gave maximum yield per hectare
- During the investigation, the best treatment combination was obtained from T_2S_1 ($N_{90}P_{50}K_{40}$ kg ha^{-1} with 20 cm × 10 cm) having yield potentiality of 1.24 t/ha

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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