INFLUENCE OF PHOSPHORUS FERTILIZATION AND SEED RATES ON YIELD COMPONENTS AND YIELD OF BLACK CUMIN (*Nigella sativa* L.)

Abstract

The experiment was carried out at the "Horticulture Farm" of Sher-e-Bangla Agricultural University, Dhaka, Bangladesh during November 2019 to March 2020 to study influence of phosphorus fertilization and seed rates on yield components and yield of black cumin. The experiment consisted of two factors. Factor A: Four levels of phosphorus viz., P_0= control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P $ha^{-1}$and P_3= 45 kg P $ha^{-1}$and Factor B: Three seed rates viz., R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds $ha^{-1}$and R_3= 12 kg seeds ha^{-1}. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data were recorded on growth, yield components and yield of black cumin and significant variation was observed for most of the studied characters. Growth related data was maximum on P_3 (45 kg P ha^{-1}) treatment but in case of seed yield, P_2 (40 kg P ha^{-1}) treatment showed the best result. In case of growth characters, R_1 (8 kg seeds ha^{-1}) treatment revealed the best result but in case of seed yield, R_2 (10 kg seeds ha^{-1}) treatment showed the best result. In case of different levels of phosphorus, the highest seed yield (1.22 t ha^{-1}) was obtained from P_2 (40 kg P ha^{-1}) treatment whereas the lowest seed yield (0.98 t ha^{-1}) was obtained from P_0 (control) treatment. In case of different seed rates, the highest seed yield (1.14 t ha^{-1}) was obtained from R_2 (10 kg seeds ha^{-1}) treatment whereas the lowest seed yield (1.07 t ha^{-1}) was obtained from R_3 (12 kg seeds ha^{-1}) treatment. So, it was observed that the highest seed yield (1.27 t ha^{-1}) was obtained from P_2R_2 (40 kg P ha^{-1}+ 10 kg seeds ha^{-1}) treatment combination. On the other hand, the lowest seed yield (0.94 t ha^{-1}) was obtained from of P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination. So, it was revealed that the P_2R_2 treatment combination appeared to be best for achieving the higher growth and seed yield of black cumin.

1. Introduction

Nigella (*Nigella sativa* L.) is well known as black cumin or kalojira. The name nigella derives from the Latin nigellus or niger, meaning black kalajira is an annual herbaceous plant belonging to the Ranunculaceae family. *Nigella* is an important seed spice has originated from Mediterranean region of Asia to North India. *Nigella* is widely cultivated throughout South Europe, Syria, Egypt, Saudi Arabia, Iran, Pakistan, India and Turkey [1]. In Bangladesh, it covers 14742 hectares of land, with total annual production of 16526 tons [2], over the Faridpur, Sariatpur, Madaripur, Pabna, Sirajganj, Jessore, Kushtia, Bogra, Rangpur and Natore districts [3,4]. The ripe seed of black cumin contains 7% moisture, 4.34% ash, 23% protein, 0.39% fat, 4.99% starch and 5.44% raw fiber [5]. The seeds are rich in fats, fiber, and minerals such as Fe, Na, Cu, Zn, P, Ca and vitamins such as ascorbic acid, thiamin, niacin, pyridoxine, and folic acid [6]. *N. sativa* seeds contain 30-35% oil and 0.5-1.5% essential oil which have several uses for pharmaceutical and food industries [7]. Seed has essence and a bitter nigeline substance. Black cumin seeds contain protein, alkaloids (nigellicines andnigelledine), saponin (α-hederin) fixed and essential oil [8]. 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, cardio-protective, gastro-protective, anti-asthmatic, nephron-protective, hepato-protective, anti-inflammatory, immune-modulatory, neuro-protective, anti-convulsant, anxiolytic, antioxidant, anti-nociceptive, anti-oxytocic, contraceptive, anti-bacterial, anti-fungal and anthelmintic activities were immensely appreciated. The major medicinal components are *thymoquinone*and *nigellone* (a dimer of thymoquinone). These were attributed to impart anti-tumour, anti-inflammatory and anti-diabetic properties [9,10].The yield of Black cumin in our country is not satisfactory in comparison to our requirement. Now-a-days, nutrients content in soil is the most limiting factor for proper growth and yield of plants. The requirements of different plant nutrients vary with different crops. Phosphorus (P) is critical in plant metabolism which plays an important role in cellular energy transfer, respiration, photosynthesis and it is a key structural component of nucleic acids coenzymes, phosphorproteins and phospholipids. Phosphorus fertilization is a major input in crop production [11]. Phosphorus is essential for the general health of the plant and 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. Plant growth and seed yield was increased when phosphorus was applied [12,13]. Seed rate is one of the main key factors for obtaining high yield and quality in the production of crops. Seed rate is the key factor determining effecting the yield and yield components. Several studies carried out in countries where systematically cultivated, have demonstrated that suitable seed rate can increase the growth and yield of *N. sativa* [14]. Unfortunately, very

limited researches have been carried out regarding the effect of phosphorus fertilization and seed rates on yield components and yield of black cumin (*Nigella sativa* L.). A detailed and systematic study is needed to find out the effect of phosphorus fertilization, influence of seed rates and suitable combination of phosphorus fertilization and seed rates for better growth and higher seed yield of black cumin in bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site and Experimental Framework The research work was conducted at "Horticulture Farm" of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, during the period from November 2019 to March 2020. The location of the site was 23°74′ N Latitude and 90°35′ E Longitude with an elevation of 8.2 meters from the sea level (Anon, 1987). The two-factorial experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were distributed randomly. There were 36 unit plots altogether in the experiment. The size of each plot was 1.2 m × 1.2 m. The distance maintained between two blocks and two plots were 50 cm and 50cm, respectively. The plots were raised up to 10 cm.

2.2 Planting Materials In this experiment black cumin variety, BARI Kalozira-1 was used. BARI Kalozira-1 was developed by Spices Research Centre, BARI in 2009. It's average plant height is 55-60cm, number of primary branches is 5-7, number of pods/plant is 20-25, number of seeds/pod is 75-80, seed weight/pod is 0.20-0.27g, seed weight/plant is 5-7g, 1000 seeds weight is 3.00 - 3.25 g.

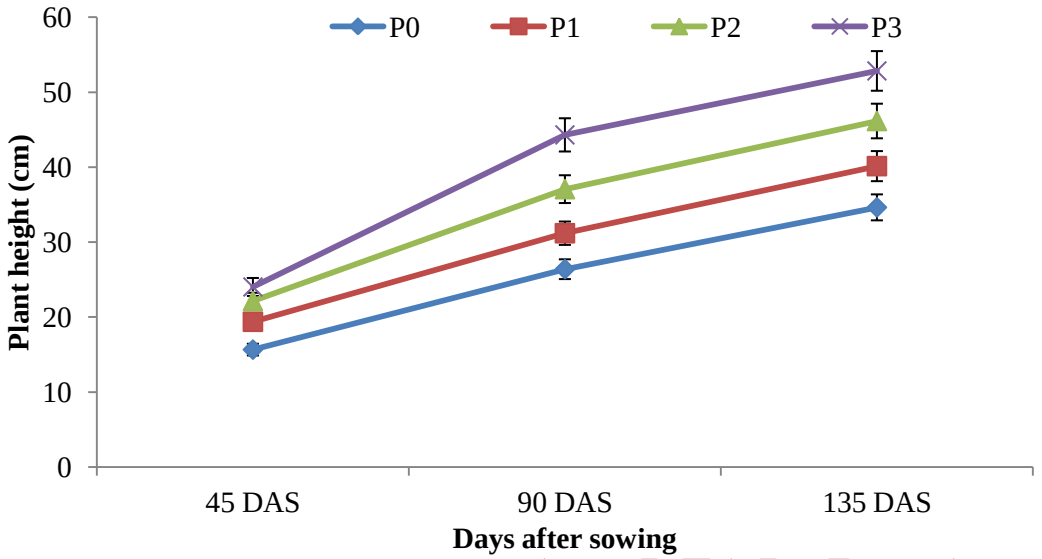
2.3 Application of manures and fertilizers The source of N, P and K were urea, triple super phosphate and muriate of potash. Half of urea and total amount of muriate of potash fertilizers of each plot were applied and incorporated into soil during final land preparation. Rest of the urea was top dressed after 30 days of sowing (DAS). Triple super phosphate was applied as per treatment. Cowdung @ 5 t per hectare was applied during the land preparation.

2.4 Statistical Analysis The collected data were compiled and tabulated. Statistical analysis was done on various plant characters to find out the significance of variance resulting from the experimental treatments. Data were analyzed using analysis of variance (ANOVA) technique with the help of computer package program MSTAT-C (software) and the mean differences were adjudged by least significant difference test (LSD) as laid out by [15].

3. RESULTS AND DISCUSSION

3.1 Plant height (cm)

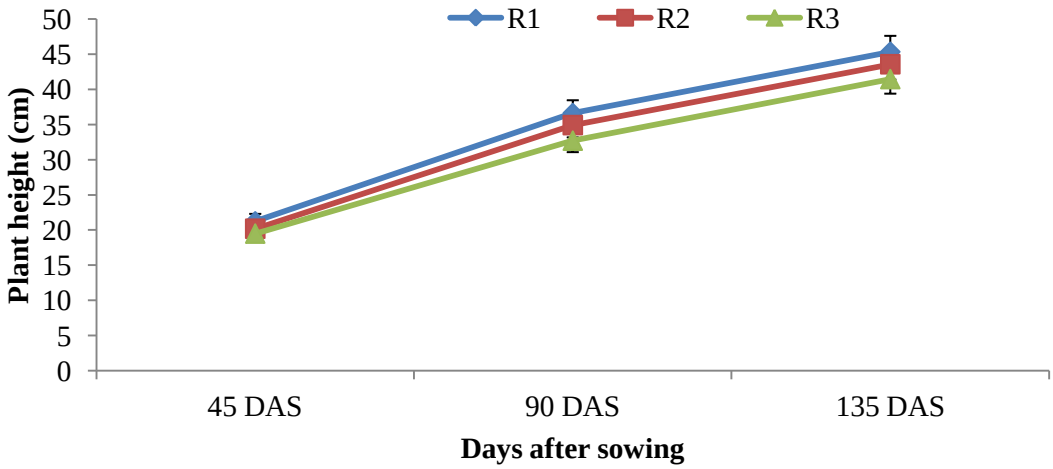
Statistically significant variation was observed on plant height at 45, 90and 135 DAS due to different levels of phosphorus under the experiment (Fig. 1 and Appendix IX). At 135 DAS, the highest plant height (52.84 cm) was obtained from P_3 (45 kg P ha^{-1}) treatment and the lowest plant height (34.64 cm) was revealed from P_0 (control) treatment. It was revealed that the plant height increased with the increase in days after sowing (DAS) i.e., 45, 90and 135 DAS. It also revealed that the plant height increased with different levels of phosphorus as well. Similar results were also observed by [9,16,17]. They reported that phosphorus fertilizer increases the plant height.



Here, P_0=control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P ha^{-1} and P_3= 45 kg P ha^{-1}

Fig.1. Effect of different levels of phosphorus on plant height at different days after sowing of black cumin

Seed rates showed significant influence on the height of black cumin plants at 45, 90 and 135 DAS (Fig. 2). At 135 DAS, the highest plant height (45.33 cm) was observed from R_1 (8 kg seeds ha^{-1}) treatment. On the other hand the lowest plant height (41.45 cm) was observed from R_3 (12 kg seeds ha^{-1}) treatment. The result of the study was in coincided with the findings of [18] who reported that seed rate significantly affected plant height.



Here, R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

Fig. 2. Effect of seed rates on plant height at different days after sowing of black cumin

Significant influence was observed on plant height due to the combined effect of different levels of phosphorus and seed rates (Table 1). From the results of the experiment showed that the highest plant height at 135 DAS (55.18 cm) was observed from the treatment combination of P_3R_1 (45 kg P ha^{-1} + 8 kg seeds ha^{-1}). On the other hand the lowest plant height at 135 DAS (32.81 cm) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

3.2 Number of primary branches per plant

Significant variation was observed on number of primary branches per plant of black cumin due to different levels of phosphorus under the experiment (Table 2). At 135 DAS, the maximum number of primary branches per plant (8.39) was obtained from P_3 (45 kg P ha^{-1}) treatment where minimum number of primary branches per plant (5.43) was observed from P_0 (control) treatment. It was revealed that the number of primary branches per plant increased

with the increase in days after sowing (DAS). It also revealed that the number of primary branches per plant increased with different levels of phosphorus as well. [16] observed the similar trends.

Statistically seed rates showed significant variation on number of primary branches per plant of black cumin (Table 3). At harvest, the maximum number of primary branches per plant (7.26) was observed from R_1 (8 kg seeds ha^{-1}) treatment. On the other hand the minimum number of primary branches per plant (6.64) was observed from R_3 (12 kg seeds ha^{-1}) treatment. [19] found the similar results.

Combined effect of different levels of phosphorus and seed rates significantly influenced by number of primary branches per plant (Table 4). At harvest, the maximum number of primary branches per plant (8.67) was achieved from P_3R_1 (45 kg P ha^{-1} + 8 kg seeds ha^{-1}) treatment combination which was statistically similar (8.40) to P_3R_2 treatment. On the other hand the minimum number of primary branches per plant (4.92) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

Table 1.Combined effect of different levels of phosphorus and seed rates on plant height at different days after sowing of black cumin

Treatment Combinations	Plant height (cm) at		
	45 DAS	**90 DAS**	**135 DAS**
P_0R_1	16.75 h	28.15 hi	36.19 gh
P_0R_2	15.67 i	26.53 i	34.92 hi
P_0R_3	14.55 j	24.48 j	32.81 i
P_1R_1	20.52 f	32.41 f	42.27 ef
P_1R_2	19.15 g	31.33 fg	40.53 f
P_1R_3	18.47 g	29.85 gh	37.62 g
P_2R_1	22.81 cd	39.13 d	47.67 c
P_2R_2	22.00 de	37.28 d	46.19 cd
P_2R_3	21.62 e	34.81 e	44.63 de
P_3R_1	24.83 a	46.75 a	55.18 a
P_3R_2	23.91 ab	44.50 b	52.60 b
P_3R_3	23.33 bc	41.67 c	50.75 b
$LSD_{(0.05)}$	0.94	1.89	2.47
CV%	2.75	3.22	3.36

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, $P_{0=}$ control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P ha^{-1} and P_3= 45 kg P ha^{-1}, R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

4.3 Days to first flowering

Significant variation on days to first flowering of black cumin was observed due to different levels of phosphorus (Table 2). The minimum days to first flowering of black cumin (51.31) was obtained from P_3 (45 kg P ha^{-1}) treatment. On the other hand the maximum days to first flowering of black cumin (57.52) was obtained from P_0 (control) treatment. It was revealed that the days to first flowering of black cumin increased with the different levels of phosphorus as well. [9] observed the similar results.

Statistically significant difference on days to first flowering of black cumin was observed due to varied seed rates (Table 3). It was revealed that the minimum days to first flowering of black cumin (53.61) was obtained from R_1 (8 kg seeds ha^{-1}) treatment. On the other hand the maximum days to first flowering of black cumin (55.23) was observed from R_3 (12 kg seeds ha^{-1}) treatment which was statistically similar (54.50) to R_2 treatment. [19] reported that days to flowering were significantly influenced by the seed rate.

Combined effect of different levels of phosphorus and seed rates significantly influenced by days to first flowering of black cumin (Table 4). From the results of the experiment revealed that the minimum days to first flowering of black cumin (50.15) was observed from P_3R_1 (45 kg P ha^{-1} + 8 kg seeds ha^{-1}) treatment combination. On the other hand the maximum days to first flowering of black cumin (58.45) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination which was statistically similar to P_0R_2, P_0R_1 and P_1R_3 treatment combination, respectively.

4.4 Days to 50% flowering

Days to 50% flowering of black cumin significantly influenced by different levels of phosphorus (Table 2). The minimum days to 50% flowering of black cumin (61.60) was obtained from P_3 (45 kg P ha^{-1}) treatment. On the other hand the maximum days to 50% flowering of black cumin (67.34) was obtained from P_0 (control) treatment. It was revealed that the days to 50% flowering of black cumin increased with the different levels of phosphorus as well. [21] found the similar trends.

Statistically significant variation on days to 50% flowering of black cumin was observed due to varied seed rates (Table 3). It was observed that the minimum days to 50% flowering of black cumin (63.58) was obtained from R_1 (8 kg seeds ha^{-1}) treatment. On the other hand the maximum days to 50% flowering of black cumin (65.10) was observed from R_3 (12 kg seeds ha^{-1}) treatment which was statistically similar (64.36) to R_2 treatment. The result of the experiment was in coincided with the findings of [14].

Combined effect of different levels of phosphorus and seed rates significantly influenced by days to 50% flowering of black cumin (Table 4). From the results of the experiment revealed that the minimum days to 50% flowering of black cumin (60.85) was observed from P_3R_1 (45 kg P ha^{-1} + 8 kg seeds ha^{-1}) treatment combination. On the other hand the maximum days to 50% flowering of black cumin (68.25) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination which was statistically similar to P_0R_2, P_0R_1 and P_1R_3 treatments, respectively.

Table 2. Effect of different levels of phosphorus on number of primary branches per plant, number of secondary branches per plant, days to first and 50% flowering of black cumin

Treatments	Number of primary branches per plant	Days to first flowering	Days to 50% flowering
P_0	5.43 d	57.52 a	67.34 a
P_1	6.53 c	55.44 b	65.16 b
P_2	7.56 b	53.52 c	63.28 c
P_3	8.39 a	51.31 d	61.60 d
$LSD_{(0.05)}$	0.21	1.36	1.59
CV%	3.13	2.56	2.53

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

Here, P_0= control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P ha^{-1} and P_3= 45 kg P ha^{-1}

Table 3. Effect of different levels of seed rates on number of primary branches per plant, number of secondary branches per plant, days to first and 50% flowering of black cumin

Treatments	Number of primary branches per plant	Days to first flowering	Days to 50% flowering
R_1	7.26 a	53.61 b	63.62 b
R_2	7.03 b	54.50ab	64.36 ab
R_3	6.64 c	55.23 a	65.10 a
$LSD_{(0.05)}$	0.18	1.18	1.37
CV%	3.13	2.56	2.53

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

Here, R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

Table 4.Combined effect of different levels of phosphorus and seed rates on number of primary branches per plant, number of secondary branches per plant, days to first and 50% flowering of black cumin

Treatment Combinations	Number of primary branches per plant	Days to first flowering	Days to 50% flowering
P_0R_1	5.81 h	56.80 abc	66.09 abc
P_0R_2	5.55 h	57.30 ab	67.67 ab
P_0R_3	4.92 i	58.45 a	68.25 a
P_1R_1	6.75 f	54.67 c-f	64.67 cde
P_1R_2	6.51 fg	55.50 b-e	65.00 bcd
P_1R_3	6.33 g	56.15 a-d	65.81 abc
P_2R_1	7.81 cd	52.82 fg	62.70 d-g
P_2R_2	7.67 d	53.75 efg	63.00 d-g
P_2R_3	7.20 e	54.00 def	64.15 c-f
P_3R_1	8.67 a	50.15 h	60.85 g
P_3R_2	8.40 ab	51.45 gh	61.75 fg
P_3R_3	8.11 bc	52.33 fgh	62.20 efg
$LSD_{(0.05)}$	0.37	2.36	2.76
CV(%)	3.13	2.56	2.53

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

Here, P_0=control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P ha^{-1} and P_3= 45 kg P ha^{-1} R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

4.5 Capsules per plant

Statistically significant variation on capsules per plant of black cumin was observed due to different levels of phosphorus (Table 5). The maximum capsules per plant (20.69) was observed from P_2 (40 kg P ha^{-1}) treatment while the minimum capsules per plant (16.32) was obtained from P_0 (control) treatment. It was observed that the number of capsules per plant increased with the different levels of phosphorus. [9] reported that highest number of capsules per plant was obtained when judicious applying of phosphorus fertilizer. [17] also observed the similar results.

Significant difference on capsules per plant of black cumin was observed due to varied seed rates (Table 6). It was revealed that the maximum capsules per plant (19.20) was obtained from R_2 (10 kg seeds ha^{-1}) treatment. On the other hand the minimum number of capsules per plant (17.86) was observed from R_3 (12 kg seeds ha^{-1}) treatment. [14] reported that number of capsule and the number of seeds in the capsule were generally affected by seed rate applications.

Combined effect of different levels of phosphorus and seed rates significantly influenced by capsules per plant of black cumin (Table 7). From the results of the experiment revealed that the maximum number of capsules per plant of black cumin (21.80) was observed from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination. On the other hand the minimum number of capsules per plant of black cumin(15.37) was observed from P_0R_3 (control + 12 kg seeds ha^{-1})treatment combination.

4.6 Length of capsule (cm)

Statistically significant variation on length of capsule of black cumin was observed due to varied levels of phosphorus (Table 5). The maximum length of capsule (1.51 cm) was observed from P_2 (40 kg P ha^{-1}) treatment while the minimum length of capsule (1.11 cm) was obtained from P_0 (control) treatment. It was observed that the length of capsule per plant increased with the different levels of phosphorus. [17] found the similar result.

Significant difference on length of capsule per plant of black cumin was observed due to varied seed rates (Table 6). It was revealed that the maximum length of capsule (1.35 cm) was obtained from R_2 (10 kg seeds ha^{-1}) treatment. On the other hand the minimum length of capsule (1.25 cm) was observed from R_3 (12 kg seeds ha^{-1}) treatment. [20] observed the similar trends.

Combined effect of different levels of phosphorus and seed rates significantly influenced by length of capsule per plant of black cumin (Table 7). From the results of the experiment revealed that the maximum length of capsule (1.59 cm) was observed from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination. On the other hand the minimum length of capsule (1.07 cm) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

4.7 Breadth of capsule (cm)

Significant variation on breadth of capsule of black cumin was observed due to varied levels of phosphorus (Table 5). The maximum breadth of capsule (1.05 cm) was obtained from P_2 (40 kg P ha^{-1}) treatment while the minimum breadth of capsule (0.77 cm) was obtained from P_0 (control) treatment. It was revealed that the breadth of capsule per plant increased with the different levels of phosphorus. [22]revealed the similar result.

Marked difference on breadth of capsule per plant of black cumin was observed due to varied seed rates (Table 6). It was revealed that the maximum breadth of capsule (0.94 cm) was obtained from R_2 (10 kg seeds ha^{-1}) treatment. On the other hand the minimum breadth of capsule (0.87 cm) was observed from R_3 (12 kg seeds ha^{-1}) treatment. [18] reported that increase the seed rate decreased the breadth of capsule relate to the yield.

Combined effect of different levels of phosphorus and seed rates significantly influenced by breadth of capsule per plant of black cumin (Table 7). From the results of the experiment revealed that the maximum breadth of capsule (1.10 cm) was observed from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination. On the other hand the minimum breadth of capsule (0.74 cm) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

4.8 Number of seeds per capsule

Number of seeds per capsule of black cumin significantly influenced bythe different levels of phosphorus (Table 5). The maximum number of seeds per capsule (80.07) was observed from P_2 (40 kg P ha^{-1}) treatment while the minimum number of seeds per capsule (66.24) was obtained from P_0 (control) treatment. It was revealed that the number of seeds per capsule increased with the increase of phosphorus. Similar results were also observed by [17,23,24]. They reported that number of capsules and number of seeds per capsule increased with level of application of P and generally maximum values were observed in highest P application.

Statistically significant influence on number of seeds per capsule of black cumin was observed due to varied seed rates (Table 6). It was revealed that the maximum number of seeds per capsule of black cumin (74.18) was achieved from R_2 (10 kg seeds ha^{-1}) treatment which was statistically identical (72.64) to R_1 treatment. On the other hand the minimum number of seeds per capsule (70.92) was observed from R_3 (12 kg seeds ha^{-1}) treatment. Increasing seed rate inversely affected yield components per plant. [19] observed the similar result.

Combined effect of different levels of phosphorus and seed rates significantly influenced by number of seeds per capsule of black cumin (Table 7). From the results of the experiment observed that the maximum number of seeds per capsule of black cumin (82.15) was observed from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination which was statistically similar (79.93) to P_2R_1 treatment combination. On the other hand the minimum number of seeds per capsule (64.71) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

4.9. 1000-seeds weight (g)

Significant variation on 1000-seeds weight was observed due to different levels of phosphorus (Table 5). From the results of the experiment showed that the maximum 1000-seeds weight (3.08 g) was obtained from P_2 (40 kg P ha^{-1}) treatment. On the other hand the minimum1000-seeds weight (2.74g) was obtained from P_0 (control) treatment. [24]reported that the application of nutrient (NPK) elements had positive effect on plant height, branches per plant, capsule setting, umbels per plant, capsules per plant, capsule size, seeds per capsule, 1000-seed weight and seed yield of black cumin.

Statistically significant influence on 1000-seeds weight was observed due to different seed rates under the present experiment (Table. 6). The maximum1000-seeds weight (2.94 g) was obtained from R_2 (10 kg seeds ha^{-1}) treatment. On the other hand the minimum1000-seeds weight (2.84 g) was observed from R_3 (12 kg seeds ha^{-1}) treatment. [14,25] observed the similar results.

Combined effect of different levels of phosphorus and seed rates significantly influenced by1000-seeds weight (Table 7). From the results of the experiment revealed that the maximum1000-seeds weight (3.15 g) was observed from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination which was statistically similar (3.08 and 3.02) to treatment combination of P_2R_1 and P_2R_3. On the other hand the minimum1000-seeds weight (2.68 g) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

4.10 Yield per plot (g)

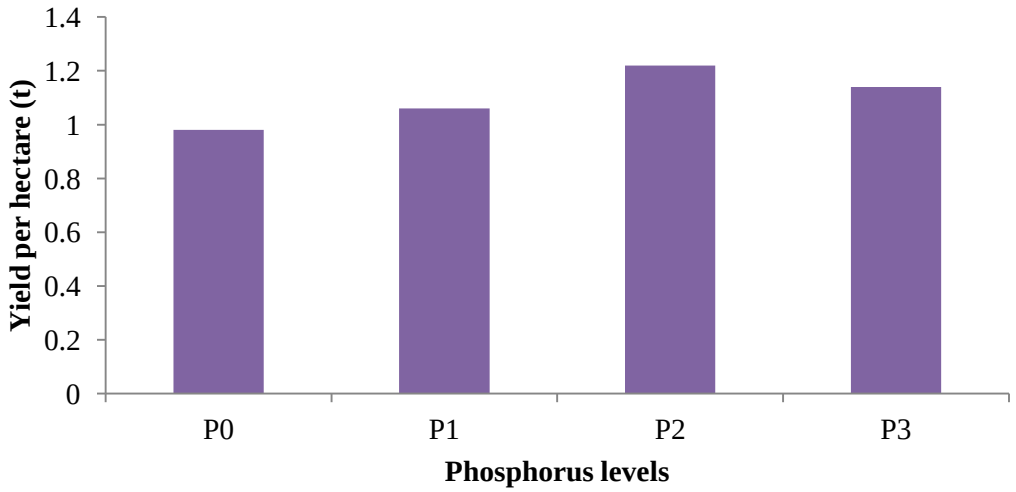
Significant variation on yield per plot was observed due to varied levels of phosphorus (Table 5). From the results of the experiment showed that the highest yield per plot (175.68 g) was obtained from P_2 (40 kg P ha^{-1}) treatment. On the other hand the lowest yield per plot (141.08 g) was obtained from P_0 (control) treatment. [9,16,17,21,22,26] observed the similar results. [23] reported that use a combination of 45 kg N and 40 kg P ha^{-1} followed by 15 kg N and 20 kg P ha^{-1} for black cumin production in the area.

Statistically significant influence on yield per plot was observed due to varied seed rates during the experimentation (Table 6). It was observed that the highest yield per plot (164.46 g) was obtained from R_2 (10 kg seeds ha^{-1}) treatment. On the other hand the lowest yield per plot (154.45 g) was observed from R_3 (12 kg seeds ha^{-1}) treatment. [20] reported that yield and yield attributing factors such as seed yield per plot and seed yield ha^{-1} (kg) was significantly influenced by the seed rate. Seed yield increased from 462 kg ha^{-1} to 634 kg ha^{-1} as seed rate increased from 5 kg ha^{-1} to 20 kg ha^{-1} and showed a decrease in yield from 601 kg ha^{-1} to 507 kg ha^{-1} as inter-row spacing increased from 20 cm to 40 cm.

Yield per plot showed significant influence due to the combined effect of different levels of phosphorus and seed rates (Table 7). From the results of the experiment observed that the highest yield per plot (182.88 g) was obtained from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination. On the other hand the lowest yield per plot (139.27 g) was observed from P_0R_3 (control + 12 kg seeds ha^{-1}) treatment combination.

4.11 Yield per hectare (t)

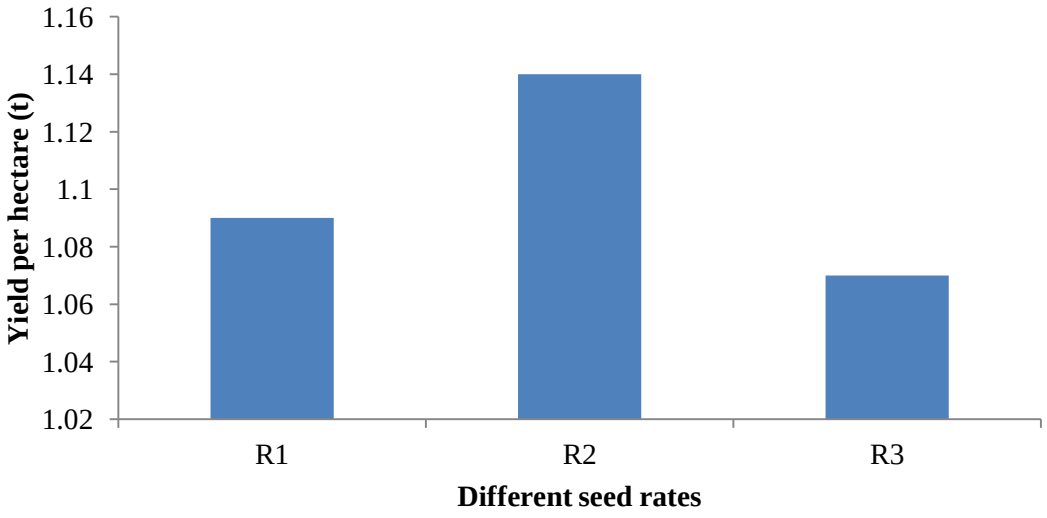
Significant variation was observed on yield per hectare due to different levels of phosphorus under the present study (Fig. 3). From the results of the experiment showed that the highest yield per hectare (1.22 t) was obtained from P_2 (40 kg P ha^{-1}) treatment. On the other hand the lowest yield per hectare (0.98 t) was obtained from P_0 (control) treatment. The result of the experiment were in coincided with the findings of [14,21,23,26]. [24] reported that The highest seed yield (1277 kg ha^{-1}) was obtained from 75% RDCF + 25% cowdung-N treatment followed by 100% RDCF ($N_{80}P_{45}K_{50}S_{20}Zn_5B_2$ kg ha^{-1}) and the lowest seed yield (420 kg ha^{-1}) was recorded with 50% RDCF.



Here, P_0= control, P_1= 35 kg ha^{-1}, P_2= 40 kg ha^{-1} and P_3= 45 kg ha^{-1}

Fig. 3.Effect of different levels of phosphorus on yield per hectare of black cumin

Statistically significant influence on yield per hectare was observed due to different seed rates (Fig. 4). It was revealed that the highest yield per hectare (1.14 t) was revealed from R_2 (10 kg seeds ha^{-1}) treatment. On the other hand the lowest yield per hectare (1.07 t) was obtained from R_3 (12 kg seeds ha^{-1}) treatment. [20] observed the similar result. They reported that seed yield ha^{-1} (kg) was significantly influenced by the seed rate. [25] reported that 8 kg seed/ha would be the optimum seed rate and line sowing in raised bed would be the most effective method for higher seed yield of the black cumin. But for broadcasting seeds should be shown with 10 kg/ha.



Here, R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

Fig. 4. Effect of different seed rates on yield per hectare of black cumin

Combined effect of different levels of phosphorus and seed rates significantly influenced by yield per hectare of black cumin (Table 7). From the results of the experiment revealed that the highest yield per hectare (1.27 t) was observed from P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination which was statistically similar (1.21 t) to P_2R_1 treatment combination. On the other hand the lowest yield per hectare (0.94 t) was obtained from P_0R_3 (control + 12 seeds kg ha^{-1}) treatment combination.

Table 5. Effect of different levels of phosphorus on number of capsules per plant, length of capsule, breadth of capsule and number of seeds per capsule, 1000-seeds weight (g), yield per plot (g) of black cumin

Treatments	Capsules per plant	Length of capsule (cm)	Breadth of capsule (cm)	Number of seeds per capsule	1000-seeds weight (g)	Yield per plot (g)
P_0	16.32 d	1.11 d	0.77 d	66.24 d	2.74 d	141.08 d
P_1	17.93 c	1.24 c	0.85 c	69.59 c	2.83 c	154.46 c
P_2	20.69 a	1.51 a	1.05 a	80.07 a	3.08 a	175.68 a
P_3	19.14 b	1.35 b	0.95 b	74.42 b	2.93 b	164.64 b
$LSD_{(0.05)}$	0.43	0.04	0.02	1.87	0.08	2.28
CV%	2.42	3.37	2.54	2.65	2.92	1.47

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

Here, P_0=control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P ha^{-1} and P_3= 45 kg P ha^{-1}

Table 6. Effect of different levels of seed rates on number of capsules per plant, length and breadth of capsule and number of seeds per capsule, 1000-seeds weight (g), yield per plot (g) of black cumin

Treatments	Capsules per plant	Length of capsule (cm)	Breadth of capsule (cm)	Number of seeds per capsule	1000-seeds weight (g)	Yield per plot (g)
R_1	18.51 b	1.30 b	0.91 b	72.64 a	2.89 ab	157.98 b
R_2	19.20 a	1.35 a	0.94 a	74.18 a	2.94 a	164.46 a
R_3	17.86 c	1.25 c	0.87 c	70.92 b	2.85 b	154.45 c
$LSD_{(0.05)}$	0.37	0.03	0.01	1.62	0.07	1.97
CV%	2.42	3.39	2.54	2.65	2.92	1.47

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

Table 7.Combined effect of different levels of phosphorus and seed rates on capsules per plant, length of capsule, breadth of capsule and number of seeds per capsule, 1000-seeds weight (g), yield per plot (g), yield per hectare (t) of black cumin

Treatment Combinations	Capsules per plant	Length of capsule (cm)	Breadth of capsule (cm)	Number of seeds per capsule	1000-seeds weight (g)	Yield per plot (g)	Yield per hectare (t)
P_0R_1	16.48 h	1.12 hi	0.78 g	66.77 hi	2.75 fg	141.12 h	0.98fg
P_0R_2	17.11 gh	1.15 h	0.80 g	67.25 hi	2.78 fg	146.75 g	1.01 fg
P_0R_3	15.37 i	1.07 i	0.74 h	64.71 i	2.68 g	135.36 i	0.94 g
P_1R_1	18.00 ef	1.25 fg	0.85 f	69.52 fgh	2.83 def	152.40 f	1.05 def
P_1R_2	18.33 e	1.27 f	0.88 f	70.81 fg	2.85 def	161.18 e	1.11cde
P_1R_3	17.47 fg	1.19 gh	0.81 g	68.44 gh	2.80 efg	149.81 fg	1.04 ef
P_2R_1	20.40 b	1.51ab	1.04 b	79.93 ab	3.08 ab	174.24 b	1.21ab
P_2R_2	21.80 a	1.59 a	1.10 a	82.15 a	3.15 a	182.88 a	1.27 a
P_2R_3	19.87 bc	1.43 c	1.01 bc	78.12 bc	3.02 abc	169.92 c	1.18 bc
P_3R_1	19.15 cd	1.35 de	0.95 de	74.33 de	2.93 cde	164.16 de	1.14 bc
P_3R_2	19.56 c	1.39 cd	0.98 cd	76.50 cd	2.97 bcd	167.04 cd	1.16bc
P_3R_3	18.72 de	1.30 ef	0.93 e	72.42 ef	2.89 c-f	162.72 e	1.13bcd
$LSD_{(0.05)}$	0.75	0.07	0.03	3.25	0.14	3.95	0.08
CV(%)	2.42	3.39	2.54	2.65	2.92	1.47	4.52

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.
Here, P_0=control, P_1= 35 kg P ha^{-1}, P_2= 40 kg P ha^{-1} and P_3= 45 kg P ha^{-1}, R_1= 8 kg seeds ha^{-1}, R_2= 10 kg seeds ha^{-1} and R_3= 12 kg seeds ha^{-1}

CONCLUSION

This study observed that different levels of phosphorus and seed rates have a positive effect on growth and yield of black cumin. In case of yield of black cumin, P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) treatment combination was given the better performance of all the yield contributing parameters and yield (1.27 t per ha) of black cumin than the other treatment combinations. So, the treatment combination of P_2R_2 (40 kg P ha^{-1} + 10 kg seeds ha^{-1}) can be repeated in different agro ecological zones of Bangladesh for better yield of black cumin.

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