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RESEARCH PAPER

Effect of Plant Spacing on Growth and Yield of Black Cumin

Md. Zafar Ahmed[1*], Dr. Mohammad Zakaria[2], Moriom Akter Mousumi[3], Md. Faridujjaman[4], Esmat Jahan Ami[5]

[1]Upazilla Agriculture Officer, Department of Agricultural Extension, Ministry of Agriculture, Bangladesh.
[2]Professor, Department of Horticulture, Bangabandhu Sheikh Mujibur Rahman Agricultural University.
[3]Department of Plant Pathology, Patuakhali Science and Technology University, Dumki, Patuakhali-8602, Bangladesh.
[4]Additional Deputy Director, Department of Agricultural Extension, Ministry of Agriculture, Bangladesh.
[5]Farm Broadcasting Officer, Agriculture Information Service, Ministry of Agriculture, Bangladesh.

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*Corresponding author:
zafar.pstu5@gmail.com

ABSTRACT

An experiment was conducted in the experimental field of Department of Horticulture, Gazipur Agricultural University, Salna, Gazipur during 20th October, 2012 to 30th April, 2013 to determine optimum spacing for black cumin. There were four different plant spacing viz. S_1 (10cm X 10cm), S_2 (15cm X 10cm), S_3 (20cm X 10cm) and S_4 (15cm X 15cm). The treatment effects were statistically analyzed and found significant in most of the parameters studied. The numbers of branches, leaf length, seed yield per plant (4.94g) were maximum in widest spacing S_4 (15cm X 15cm). On the other hand, the highest seed yield per plot (253.9g) and maximum seed yield per hectare (1.77 t) were recorded from closer spacing S_1 (10cm X 10cm) and lowest from wider spacing S_4 (15cm X 15cm).

Key words: Black cumin, Field emergence, Plant Spacing, Yield

Introduction

Black cumin (*Nigella sativa* L.), belonging to the family Ranunculaceae, is a very ancient crop which originated in the Eastern-southern Europe is generally short- lived annual herbaceous crops. It is an important spice crop known as '*Kalojeera*' in Bangla is cultivated in winter (Rabi) season in Bangladesh. It is widely cultivated throughout South Europe, Syria, Egypt, Saudi Arabia, Iran, Pakistan, India and Turkey (Riaz *et al.*, 1996). The genus Nigella has 22 species among which *N. Sativa* is cultivated commercially. It has rich nutritional value and has many medicinal usages. Not only because of its culinary delighting properties to enhance the taste of the recipe, but also because of its high nutritional value content. A table-spoon full black cumin seeds that weigh about 6.7gm has Calories – 22, Fat – 1gm, Sodium – 1mg, Potassium – 91mg, Total carbohydrates – 3gm, Dietary fibre – 3gm, Protein – 1g (Tierram, 2005). The seed is rich in fatty acids, proteins and carbohydrates. It contains all essential amino acids and rich source of vitamins and minerals (Abu-Jadayil et al., 1999). It is claimed that the prophet Muhammad said about the black cumin seeds, "Use the black cumin seed which is a healing for all diseases except As-Sam". 'As-Sam' is death". Black cumin is produced in 3530 hectares of land, with total annual production 3675 tons. Main production areas are Faridpur, Sariatpur, Madaripur, Natore, Pabna, Sirajganj and Rajbari (Anonymous, 2012). Soil pH 7.0 to 7.5 is favorable for its production. Therefore, the crop can be grown in Bangladesh. By fulfilling our demand, the surplus produces can be export to the abroad to earn foreign currency. At present Iran export 40% of total black cumin of the world (Barros *et al.*, 2004) and earning a huge amount of foreign currency. But, unfortunately due attention has not been given to black cumin regarding research and development in Bangladesh.

Only one improved variety of black cumin named BARI Kalozira-1 released in 2009, which production is only 0.8-1.0 t/ha though seed is not available. One variety of a particular crop is not enough for production of that crop. Most of the farmers of Bangladesh use land races for black cumin cultivation and as such per hectare yield are very low. In farmers' field of some places of Bangladesh, yield is 1.19 to 1.48 t/ha (12-15 mound per acre) though average production 0.8 to 1.0 t/ha (Anonymous, 2007a) which can be increased up to 2.0 t/ha or above by using modern technology, high yielding variety and also the method of production. Sowing time and spacing influence the growth and yield of black cumin.

Important factor affecting the yield and yield contributing character of black cumin which can be manipulated to maximum yield (Babu and Mitra, 1989). The number of plant per unit area is the most important among yield components (Kafi, 2003). In suitable plant density, plants completely use environmental conditions (water, air, light and soil) and inter or intra-specific competition is minimum (Sadeghi et al., 2009). As the result, higher seed yield as well as higher cost-benefit ratio was found. The number of capsule per plant which depends on density of plant has the second rank of

importance in yield components. The number of seed per capsule is affected by environmental, field management and its number significantly varied depended on plant densities (Salomi *et al*., 1992). It is clear from the above discussion that plant spacing have positive role in attaining higher growth and yield of black cumin. Although there is a great scope of growing black cumin throughout the country, it has got very little research attention. Considering the above mentioned facts the present study was undertaken to find out the optimum spacing on growth and yield of black cumin.

Materials and Methods

The site was previously a shal forest, which was cleaned and developed for research purpose. The details of materials used and methods adopted in the present investigation are presented below.

The experimental area was located in medium high land. The soil was clay loam in texture having a P^H of 6.2. The experiment consisted of one factor as treatment such as sowing time. The details of different treatments of sowing time were as follows-S_1= 10cm X 10cm, S_2= 15cm X 10cm, S_3= 20cm X 10cm, S_4=15cm X 15cm. The field experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications.

BARI kalojeera-1 was used as plant material collected from Bangladesh Agricultural Research Institute, Gazipur. The seeds were soaked in water for 24 hours to facilitate germination. They were dried and treated by Bavistin @ 2 g/kg of seed to minimize the primary seed-borne diseases (Anonymous, 2007a)**.**

The land was well prepared by deep ploughing. Manures and fertilizers such as cow dung (10 t/ha.), MP (45 kg/ha K_20) and TSP (46 kg/ha P_20_5) and Urea (48 kg/ha N) were applied (Anonymous, 2007a) at final land preparation. The remaining Urea was applied at 40 days after sowing (DAS) of seeds as top dress followed by irrigation. The seeds were mixed with some loose soil to allow uniform sowing in rows. Continuous line sowing was followed to maintain plant to plant and row to row distance followed by thinning later on (Anonymous, 2007a). The seeds were covered with loose soil properly just after sowing and gently pressed by hands.

Irrigation, Weeding and thinning were done at regular intervals to break the soil crust and keep the land weed free after each irrigation. Bavistin @ 2 g/l was sprayed to control damping off.

The crop was harvested during 10 April to 28 April 2013. It was harvested when 50% of the capsules changed from green to straw color, stalks with capsule were dried in the sun. Seed from capsule were separated by beating with sticks and cleaned by winnowing and dried properly (8% moisture of seed).

Data were collected on daysto1st emergence, days to 50$^{\%}$ emergence, daysto1st flower bud initiation, days to 50$^{\%}$ flower bud initiation, days to1st blooming, days to blooming in 50% plants, daysto1st capsule setting, days to capsule setting in 50% plants, days to1st capsule ripening, days to capsule ripening in 50% plants, plant height(cm), number of primary branches per plant, number of secondary branches per plant, number of tertiary branches per plant, length of leaf, breath of leaf, length of capsule, capsule diameter, length of pedicle, number of seeds per capsule, number of capsule per plant, fresh seed weight per capsule, fresh seed yield per plant, dry seed weight per capsule, dry seed yield per plant, 1000 seed weight, seed yield (t/ha).

The mature seeds of all plots were harvested, cleaned and dried. Firstly, seed weight was measured with an appropriate spring scale balance and thus plot yield was obtained in kg. Then plot yield was converted into per hectare in tons.

The mean comparison of the treatments was made by the Duncan's Multiple Range Test (DMRT).

Results and Discussion

Present study was conducted to determine the spacing on the growth and yield of black cumin. The results have been presented, discussed and possible interpretations have been made under the following heads.

Days to 1st emergence

The effect of plant spacing on days to first emergence was found insignificant (Table 1). However, numerically maximum days (8.50) to first emergence were found in S_2 (15cm X 10cm) and the minimum days (8.25) to first emergence were found in S_1 (10cm X 10 cm).

Days to 50% emergence

The effect of plant spacing on days to 50% emergence was found insignificant (Table 1). However, numerically the maximum days (11.00) to 50% emergence were found in S_2 (15cm X 10cm) and the minimum days (10.58) to 50% emergence were found in S_1 (10cm X 10 cm).

Days to 1st flower bud initiation

The effect of plant spacing on days to 1st flower bud initiation was found insignificant (Table 1). However, numerically maximum days (47.08) to 1st flower bud initiation was found in S_4 (15cm X 15cm) and minimum days (46.75) to 1st flower bud initiation was found in S_1 (10cmx10 cm).

Days to 50$^{\%}$ flower bud initiation

The effect of plant spacing on days to 50% flower bud initiation was found significant (Table 1). Maximum days (54.42) to 50% flower bud initiation was observed in S_4 (15cm X 15cm) and minimum days (52.33) to 50% flower bud initiation was observed in S_2 (15cm X 10cm) which was statistically similar to S_1 (10cm X 10 cm).

Days to 1st blooming

The effect of plant spacing on days to 1st blooming was found significant (Table 2). Maximum days (61.33) to 1st blooming was observed in S_4 (15cm X 15cm) followed by S_3 (60.33) and minimum days (57.83) to 1st blooming was found in S_2 (15cm X 10cm) which was statistically similar to S_1 (58.08).

Table1. Effect of spacing on emergence and flower bud initiation in black cumin

Spacing	Days to			
	1st emergence	50% emergence	1stflowerbud initiation	50% flower bud initiation
S_1 (10cm X 10cm)	8.25	10.58	46.75	52.42 c
S_2(15cm X 10cm)	8.50	11.00	46.75	52.33 c
S_3(20cm X 10cm)	8.33	10.83	46.75	53.58 b
S_4(15cm X 15cm)	8.42	10.59	47.08	54.42 a
Level of significance	NS	NS	NS	*
CV %	7.06	5.62	1.87	1.86

Means bearing same letter(s) in a column do not differ significantly at 5% level of probability by DMRT, NS-Non-significant

Days to 50% blooming

The effect of plant spacing on days to 50% blooming was also found significantly different in black cumin (Table 2). The maximum days (68.08) to 50% blooming were observed in S_4 (15cm X 15cm) which was different from others and the minimum days (62.08) to 50% blooming was observed in S2 (15cm X 10cm) which was statistically similar to S1 (10cm X 10cm).

Days to1st capsule setting

The number of days required to 1st capsule setting varied significantly (Table 2) due to influence of plant spacing. The maximum days (76.33) to 1st capsule setting was observed in S_4 (15cm X 15cm) which was different from others and the minimum days (70.25) to 1st capsule setting was observed in S_1 (10cm X cm) which was statistically similar to S_2 (15cm X 10cm).

Table 2. Effect of spacing on blooming and capsule setting in black cumin

Spacing	Days to		
	1st blooming	50% blooming	1st capsule setting
S_1 (10cm X 10 cm)	58.08 b	62.75 c	70.25 c
S_2 (15cm X 10cm)	57.83 b	62.08 c	71.17 c
S_3 (20cm X 10 cm)	60.33 a	65.83 b	74.42 b
S_4 (15cm X 15cm)	61.33 a	68.08 a	76.33 a
Level of significance	*	*	*
CV%	2.34	3.25	2.47

Means bearing same letter (s) in a column do not differ significantly at 5% level of probability by DMRT

Days to 50% capsule setting

The effect of plant spacing on days to 50% capsule setting was also found significantly different in black cumin (Table 3). The maximum days (85.50) to 50% capsule setting was observed in S_4 (15cm X 15cm) which was different from others and the minimum days (80.58) to 50% capsule setting was observed in S_1 (10cm X 10cm) which was statistically similar to S_2 (15cm X 10 cm).

Days to 1st capsule ripening

The effect of plant spacing on days to 1st capsule ripening was also found significantly different in black cumin (Table 3). The maximum days (106.0) to 1st capsule ripening was observed in S_4 (15cm X 15cm) which was statistically similar to S_3 (15cm X 15 cm) and the minimum days (101.2) to 1st capsule ripening was observed in S_1 (10cm X 10cm).

Days to 50% capsule ripening

The effect of plant spacing on days to 50% capsule ripening was also found significantly different in black cumin (Table 3). The maximum days (116.8) to 50% capsule ripening was observed in S_4 (15cm X 15cm) which was statistically different from others and the minimum days (111.0) to 50% capsule ripening was observed in S_1 (10cm X 10cm).

Table 3. Effect of spacing on capsule setting and capsule ripening in black cumin

Spacing	Days to		
	50% capsule setting	1st capsule ripening	50% capsule ripening
S_1 (10cm X 10 cm)	80.58 c	101.2 c	111.0 d
S_2 (15cm X 10cm)	81.42 c	102.6 b	112.7 c
S_3 (20cm X 10 cm)	84.33 b	105.2 a	114.9 b
S_4 (15cm X 15cm)	85.50 a	106.0 a	116.8 a
Level of significance	*	*	*
CV%	1.60	1.32	0 .94

Means bearing same letter (s) in a column do not differ significantly at 5% level of probability by DMRT.

Plant height (cm)

The effect of plant spacing on the height of plant was also found significant (Fig. 1). At 45 Days after sowing the maximum height (13.05 cm) was recorded in S_4 (15cm X 15cm) which was statistically similar to S_3 (20cm X 10cm) and minimum plant height (11.32cm) was found in S_2 (15cm X 10cm) which each was similar to S_1 (10cm X 10cm). At 65 DAS, the maximum height (37.87 cm) was recorded in S_4 (15cmx15cm) and minimum plant height (33.87cm) was found in S_1 (10cm X 10cm) which was similar to S_3 (20cm X 10cm). At 85 DAS, the maximum height (59.72 cm) was recorded in S_4 (15cm X 15cm) which was statistically similar to S_3 (20cm X 10cm) while minimum plant height (55.78 cm) was found in S_1 (10cm X 10cm) which was different from others. The plant height was increased with the increasing of spacing. It might be due to lower inter plant competition for nutrient, space, moisture and light in wide spacing. But Rahnavard *et al.* (2010) reported that plant height increased with increasing seed rate. Toncer and Kizil (2004) also found increase plant height with increasing seed rate.

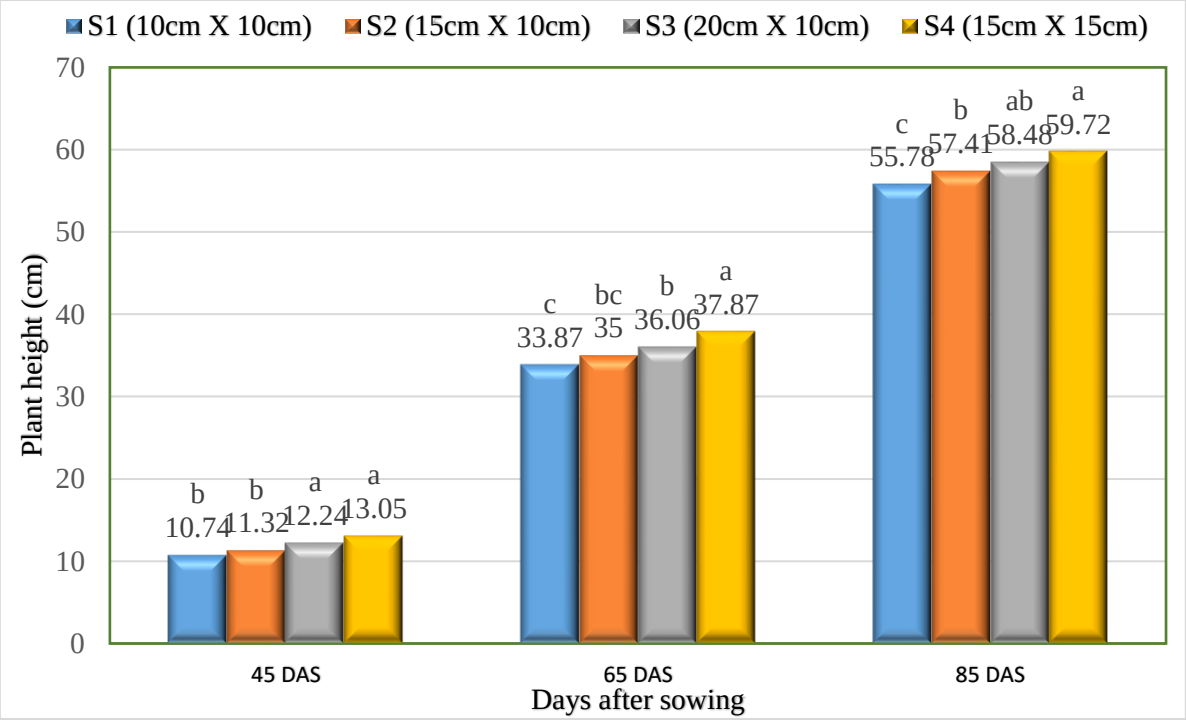

Fig.1. Effect of plant spacing on plant height at different DAS

Number of primary branches per plant

The maximum number of primary branches (7.39) was recorded in S_4 (15cm X 15cm) which was statistically similar to S_3 (20 cm X 10 cm) and the minimum number of primary branches (5.85) was observed in S_1 (10cm X 10cm). The number of primary branches increased with the increasing of spacing. It might be due to lower inter plant competition for nutrient, space, moisture and light in wide spacing.

Number of secondary branches per plant

The effect of plant spacing on the number of secondary branches also found significant (Fig.2). The maximum number of secondary branches (11.86) was recorded in S4 (15cm X 15cm) which was statistically different from others and the minimum number of secondary branches (8.41) was observed in S1 (10cm X 10cm). The number of secondary branches also increased with the increasing of spacing. It might be due to lower inter plant competition for nutrient, space, moisture and light wide spacing.

Number of tertiary branches per plant

The effect of plant spacing on the number of tertiary branches also found significant (Fig.2). The maximum number of tertiary branches (17.19) was recorded in S_4 (15cm X 15cm) which was similar to S_3 (20 cm X 10 cm) and the minimum number of tertiary branches (13.63) was observed in S_1 (10cm X 10cm). The number of tertiary branches also increased with the Increasing of spacing. It might be due to lower inter plant competition for nutrient, space, moisture and light in wide spacing.

Length of leaf

The length of leaf was significantly influenced by different plant spacing (Table 4). At 45 DAS, the maximum leaf length (7.92cm) was recorded in S_4 (15cm X 15cm) which was statistically different others. The lowest leaf length (7.18 cm) was observed in S_1 (10cm X 10cm). At 75 DAS, the maximum leaf length (4.41 cm) was recorded in S_4 (15cm X 15cm) which was statistically different from others and the lowest leaf length (3.88 cm) was observed in S_1 (10cm X 10cm). Higher vegetative growth was found in wider spacing resulting longer leaves.

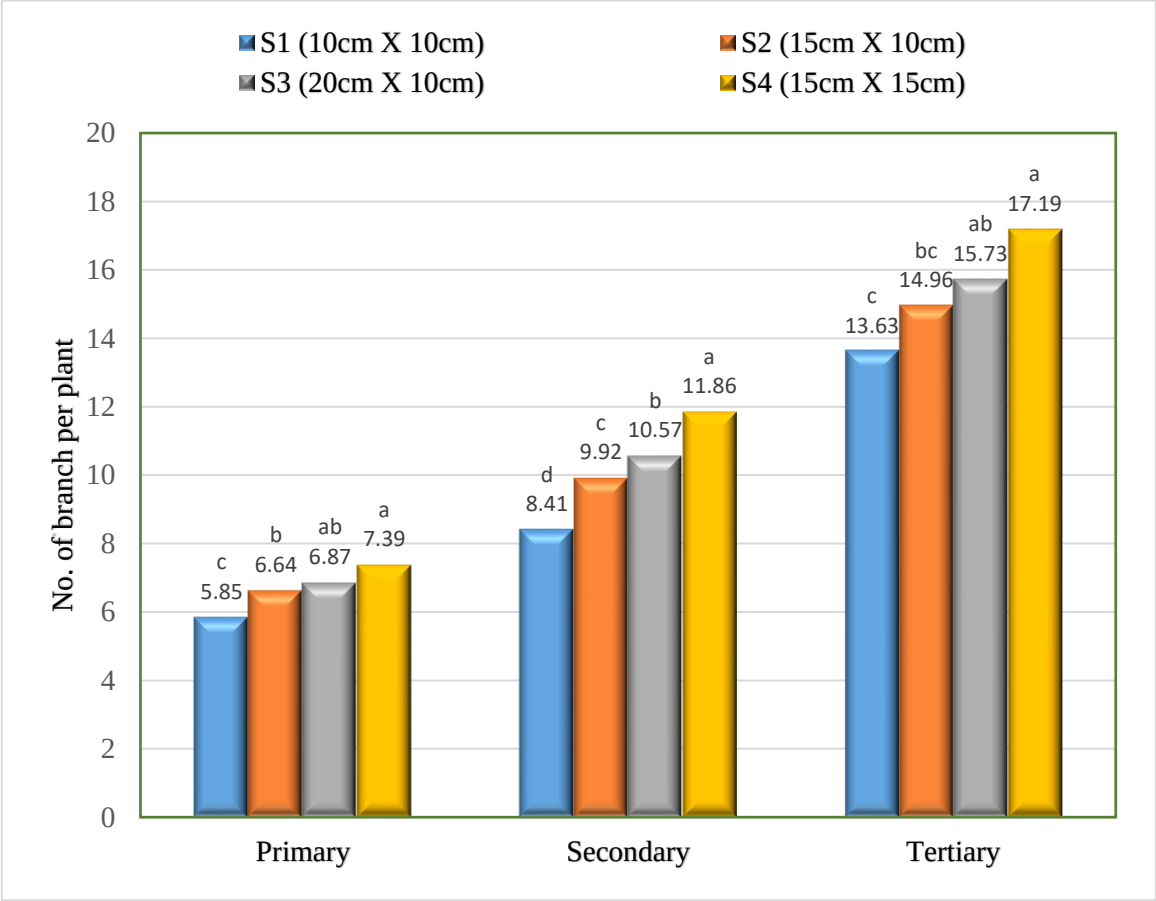

Fig.2. Effect of spacing on the number of branch/plant.

Table 4. Effect of plant spacing on the leaf length of black cumin

Spacing	Leaf length (cm)	
	45 DAS	75 DAS
S_1 (10cm x 10cm)	7.18 c	3.88 c
S_2 (15cm x 10cm)	7.31 bc	4.08 b
S_3 (20cm x 10cm)	7.46 b	4.22 b
S_4 (15cm x 15cm)	7.92 a	4.41 a
Level of significance	*	*
CV %	4.01	4.79

Means bearing same letter (s) in a column do not differ significantly at 5% level of probability by DMRT.

Breadth of leaf

The breadth of leaves significantly influenced by different plant spacing (Table 5). At 45 DAS, the maximum leaf breadth (4.04 cm) was recorded in S_4 (15cm X 15cm) which was statistically different from others. The lowest leaf length (3.57 cm) was observed in S_1 (10cm X 10cm). At 75 DAS, there was no significant difference on leaf breadth. Higher vegetative growth was found in wider spacing.

Table 5. Effect of plant spacing on the breadth of leaf in black cumin

Spacing	Leaf breadth (cm)	
	45 DAS	75 DAS
S_1 (10cm x 10cm)	3.57b	2.30
S_2 (15cm x 10cm)	3.68 b	2.61
S_3 (20cm x 10cm)	3.66 b	2.46
S_4 (15cm x 15cm)	4.04 a	2.61
Level of significance	*	NS
CV %	8.12	6.71

Means bearing same letter (s) in a column do not differ significantly at 5% level of probability by DMRT, NS-Non-significant.

Capsule length

The maximum capsule length (1.29 cm) was recorded in S_4 (15cm X 15cm) which was statistically different from others. The minimum capsule length (1.14 cm) was observed in S_1 (10cm X 10cm) which was statistically similar to S_2 (15 cm X 10 cm) and S_3 (20 cm X 10 cm). The length of capsule increased with the increasing of spacing may be due to vigorous growth of the plant in wide spacing.

Capsule diameter

The maximum capsule diameter (0.77cm) was recorded in S_4 (15cm X 15cm) which was statistically different from others. The minimum capsule diameter (0.68 cm) was observed in S_1 (10cm X 10cm) which was statistically similar to S_2 (15cm X 10cm). The diameter of capsule increased with the increasing of spacing may be due to vigorous growth of the plant in wide spacing.

Pedicle length

The maximum pedicle length (6.28 cm) was recorded in S_4 (15cm X 15cm) which was statistically different from others. The minimum pedicle length (5.64 cm) was observed in S_1 (10cm X 10cm). The pedicle length increased with the increasing of spacing may be the consequence of vigorous growth of the plant.

Table 6. Effect of plant spacing on capsule length, diameter and pedicle length in black cumin

Spacing	Capsule		Pedicle length (cm)
	Length (cm)	Diameter (cm)	
S_1 (10cm X 10cm)	1.14 b	0.68 c	5.64 c
S_2 (15cm X 10cm)	1.15 b	0.71 bc	5.87 b
S_3 (20cm X 10cm)	1.17 b	0.73 b	6.07 b
S_4 (15cm X 15cm)	1.29 a	0.77 a	6.28 a
Level of significance	**	**	**
CV %	4.55	3.81	3.65

Means bearing same letter (s) in a column do not differ significantly at 5% level of probability by DMRT.

Number of capsule per plant

The effect of plant spacing on the number of capsule per plant also found significant (Table 7). The maximum number of capsule (21.37) was recorded in S_4 (15cm X 15cm) which was statistically similar to S_3 (20cm X 10cm) and S_2 (15cm X 10cm). The minimum number of capsule (18.77) was observed in S_1 (10cm X 10cm). The number of capsule decreased with the decreasing of spacing. This might be the reduced branching and hence fewer number of capsule per plant for greater seed rate (Degehardt and Kondra, 1981; Roy and Paul, 1991). But Sadeghi *et al*. (2009) found no effect of spacing on number of capsule per plant. Arslan (1994) and Sardooyi *et al*. (2011) found that capsule per plant was higher with higher spacing.

Number of seeds per capsule

The effect of plant spacing on the number of seed per capsule also found significant (Table 7). The maximum number of seeds per capsule (89.46) was recorded in S_4 (15cm X 15cm) which was statistically similar to S_3 (20cm X 10cm) and S_2 (15cm X 10cm). The minimum number of seeds (84.89) was observed in S_1 (10cm X 10cm). The number of seed increased with the increasing of spacing. This might be due to the plant of wide spacing having bigger capsule and hence higher number of seeds per capsule. Arslan (1994) and Sardooyi *et al.* (2011) reported that the number of seeds per capsule was higher with higher spacing which corroborates the present findings.

Table 7. Effect of plant spacing on number of capsule per plant and number of seeds per capsule in black cumin

Spacing	No. of capsule per plant	No. of seeds per capsule
S_1 (10cm X 10cm)	18.77 b	84.89 b
S_2 (15cm X 10cm)	20.33 ab	86.41 ab
S_3 (20cm X 10cm)	21.34 a	89.20 a
S_4 (15cm X 15cm)	21.37 a	89.46 a
CV %	*	*
Level of significance	11.28	4.18

Means bearing same letter (s) in a column do not differ significantly at 5% level of probability by DMRT.

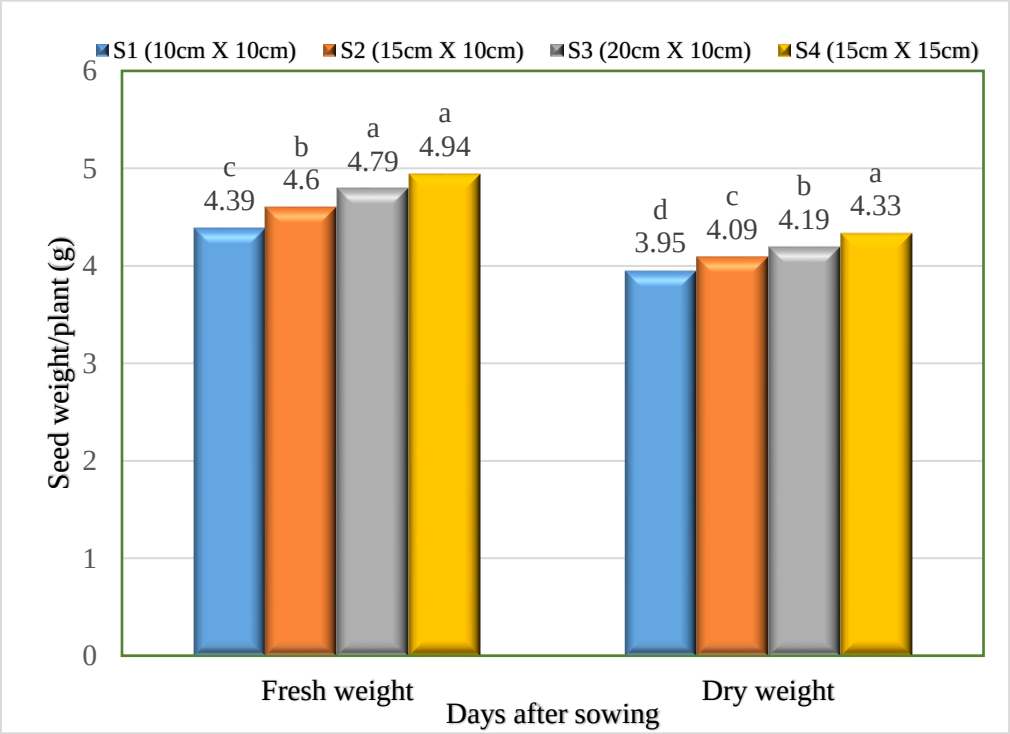

Fig.3. Effect of plant spacing on fresh seed yield and dry seed yield/plant

Fresh seed yield per plant

The maximum fresh seed yield (4.94g) was recorded in S_4 (15cm X 15cm) which was statistically different from others. The minimum fresh seed yield (4.39g) was observed in S_1 (10cm X 10cm). Fresh seed yield increased with the increasing of spacing. This might be due to the vigorous vegetative growth of plant at wide spacing.

Dry seed yield per plant

The effect of plant spacing on dry seed yield per plant also found significant (Fig.3). The maximum dry seed yield (4.33gm) was recorded in S_4 (15cm X 15cm) which was statistically different from others. Dry seed yield increased with the increasing of spacing. The minimum dry seed yield (3.95gm) was observed in S_1 (10cm X 10cm).

Dry seed weight per capsule

The effect of plant spacing on dry seed weight per capsule was found insignificant (Fig.4). However, the maximum dry weight of seed (0.19gm) was recorded in S_4 (15cm X 15cm and the minimum dry weight of seed (0.17gm) was observed in S_1 (10cm X 10cm).

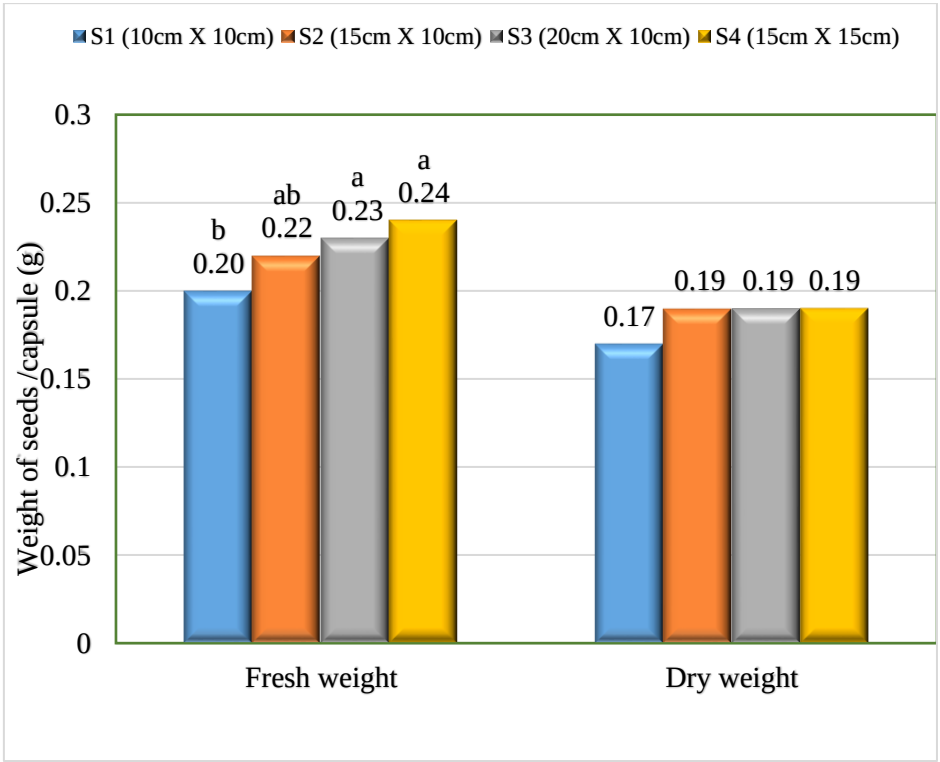

Fig.4. Effect of spacing on fresh seed weight and dry seed weight per capsule

1000 seed weight

The effect of plant spacing on 1000 seed weight was also found significant (Fig.5). The maximum 1000 seed weight (2.47g) was recorded in S_4 (15cm X 15cm) which was statistically similar to S_3 (20cm X 10cm) and the minimum 1000 seed weight (2.21g) was observed in S_1 (10cm X 10cm). 1000 seed weight increased with the increasing of spacing.

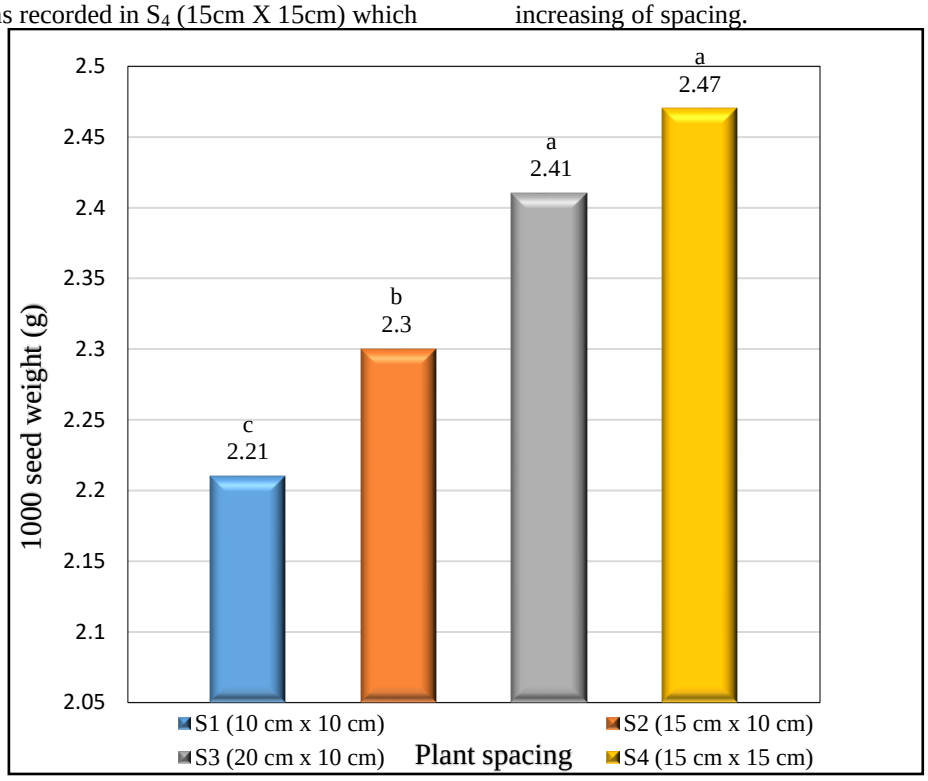

Fig.5. Effect of plant spacing on 1000 seed weight

Seed yield per plot

The effect of plant spacing on seed yield per plot was also found significant (Fig.6). The maximum seed yield per plot (253.9g) was recorded in S_1 (10cm X 10cm) which was statistically different from others. The minimum seed yield per plot (236.3g) was observed in S_4 (15cm X 15cm). Seed yield per plot was increased with the decreasing of spacing. This might be due to increased number of plant per plot and hence higher seed yield per plot.

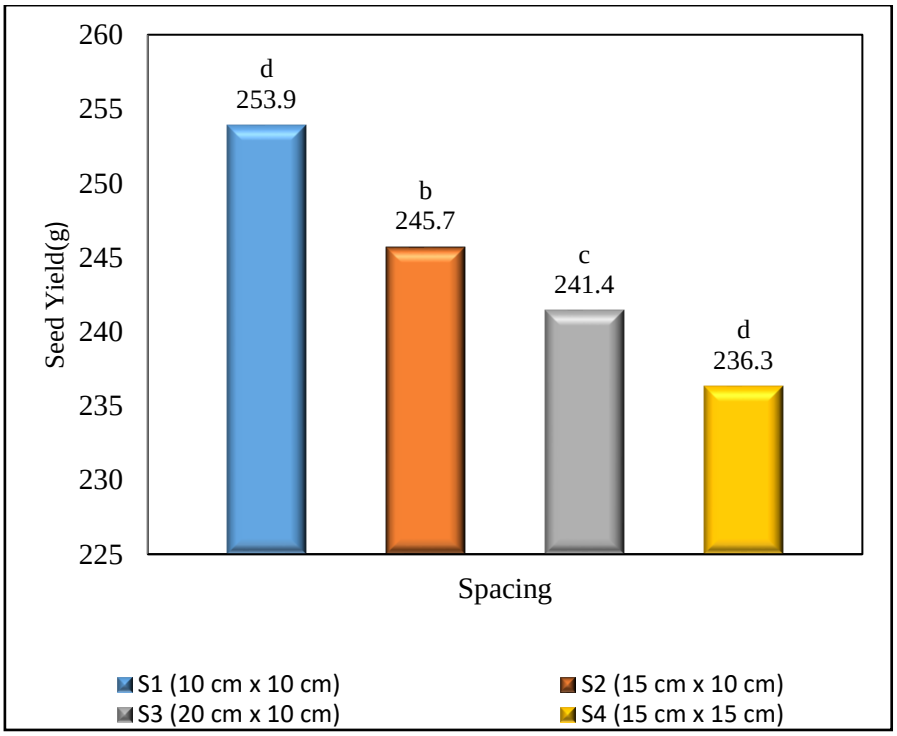

Fig.6. Effect of plant spacing on seed yield per plot.

Seed yield (t/ha)

The yield of black cumin per hectare also significantly influenced by different plant spacing (Fig.7). The maximum seed yield per hectare (1.77 t) was recorded in S_1 (10cm X 10cm) which was statistically different from others. The minimum seed yield per hectare (1.64 t) was observed in S_4 (15cm X 15cm). Seed yield per hectare increased with the decreasing of spacing. Closer spacing had higher seed yield per hectare might be due to higher number of plant per hectare. The result was supported by Sardooyi *et al.* (2011), Toncer and Kizil (2004), Zolleh *et al.* (2009) and Rahnavard *et al*. (2010) who reported higher yield of black cumin with closer spacing.

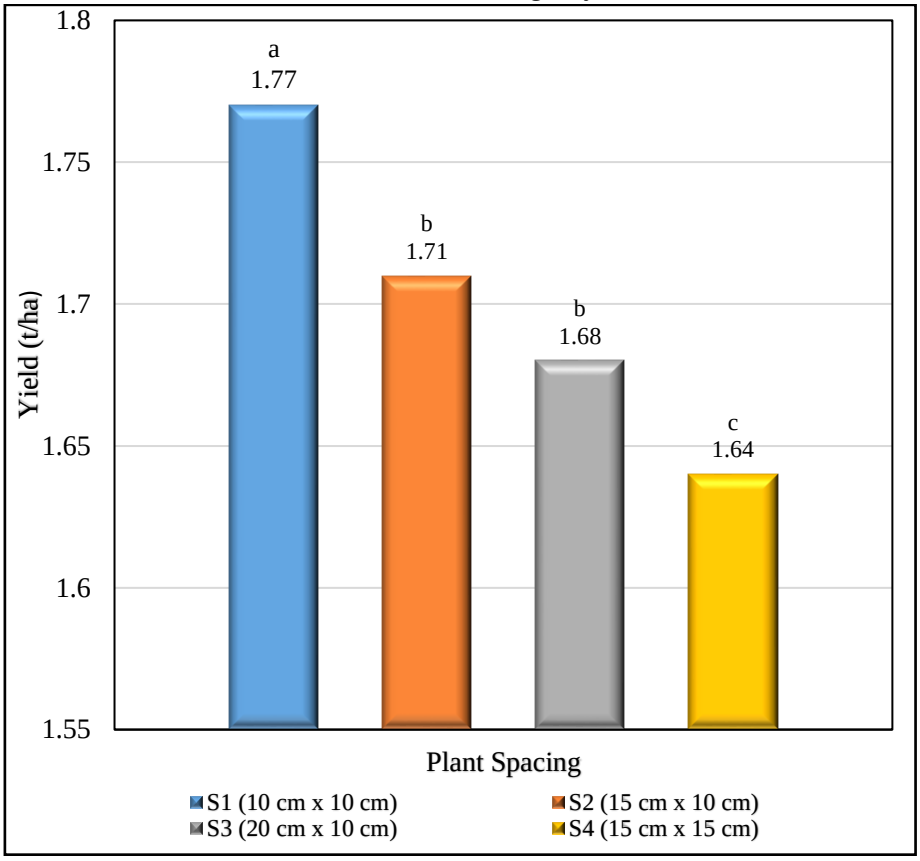

Fig.7. Effect of plant spacing on seed yield (t/ha)

Conclusion

On the basis of the results of this experiment following conclusion could be drawn: The plants planted at widest spacing S_4 (15cm X 15cm) produced maximum plant height, number of primary, secondary and tertiary branches, leaf length, capsule length, pedicle length, number of capsule per plant and number of seeds per capsule whereas the highest seed yield per plot and per hectare were recorded from closest spacing S_1 (10cm X 10cm).

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