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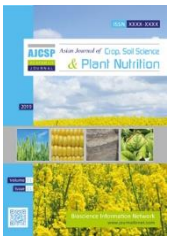

Effects of thinning and irrigation on black cumin growth quality and yield

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ABSTRACT

A field experiment observed the effects of different thinning levels and irrigation regimes on black cumin growth, yield and quality. The study was conducted in 2019-2020 at the Spices Research Sub-Centre, BARI, Lalmonirhat, using Randomized Complete Block Design (two-factor). Four thinning levels (T_1=1st thinning 25 days after sowing), (T_2=2nd thinning 35 days after sowing), (T_3=3rd thinning 45 days after sowing), T_4=control (no thinning) and three irrigation regimes (I_1= vegetative stage + flowering stage), (I_2= Vegetative stage + capsule stage), (I_3= Vegetative stage + flowering stage + capsule stage) were used as treatment. The results showed that thinning level had a significant effect on plant height (cm) but did not affect yield component, plant population, or quality (thousand grain weight and germination percentage). The combination of second thinning and irrigation regimes (vegetative stage + flowering stage) produced the highest number of branching/plant (5.96), number of capsules/plant (22.38), number of seeds/capsules (75.30), thousand seed weight (3.00g), germination percentage (92.28%). No thinning and all irrigation regimes produced the highest yield, statistically similar to second thinning and all irrigation regimes (vegetative + flowering stage).

Key Words: *Thinning, Irrigation, Black cumin and Yield*

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I. Introduction

The annual aromatic plant black cumin (*Nigella sativa* L.) is native to Southwest Asia and the Mediterranean region. Black cumin seed has approximately 21% protein, 35% carbs and 35-38 percent plant lipids and oils (Ahmad and Ghafoor, 2007). It is high in vitamins and minerals and contains all essential amino acids (Abu-Jadayil et al., 1999). Bangladesh has a total cultivable area of 14.86 million hectares, however, only 56 percent of this land is irrigated (BBS, 2007). The yearly production of black cumin is 3675 tons, with an average yield of 1.04 t/ha, from 3530 hectares of land (Anonymous, 2012). Compared to Iran (1.71-2.1 t/ha), the yield is poor (Abdolrahimi et al., 2012). In

some Bangladeshi farmer's farms, yields range from 1.19 to 1.48 t/ha (Anonymous, 2007). It is now grown in many different places of the world.

Black cumin is grown sparsely in Bangladesh, mostly in char land. During the growing season, black cumin plants are more sensitive to water. Black cumin production requires a specific irrigation schedule to promote growth, quality and seed yield. Excessive irrigation, for example, causes yowling, stunted growth and eventually death. Some researchers studied the response of black cumin to various irrigation schedules and intervals (Karim et al., 2017). Some studies have indicated that black cumin can endure moderate water stress (Bannayan et al., 2008; Mozzafari et al., 2000). Some studies studied the response of black cumin to varied irrigation intervals (Mozzafari et al., 2000; Babai, 1995). (Bannayan et al., 2008). Irrigation costs are a major barrier for small farms. In these areas, better irrigation management and crop selection are desired. Many farmers in the region are forced to restrict irrigation due to high irrigation pumping costs, insufficient irrigation capacity and limited water sources. The practice of applying water to the crop on a timely and accurate basis is called irrigation scheduling (Bannayan, 2006). Thailand and Vietnam have four times the cost of irrigation as Bangladesh. High irrigation costs in Bangladesh hinder crop productivity.

The number of plants per square unit, the number of umbrellas per plant, the number of seeds per umbrella and seed weight are all factors that affect black cumin yield. Among the yield components, the number of plants per unit area is the most essential (Kafi, 2003). Normal plant development, effective capsule formation and other features are also favored by optimal plant density. Plants fully utilize environmental circumstances (water, air, light and soil) at a sufficient plant density, resulting in expected branching, number of effective capsules and seed quality (Sadeghi et al., 2009). Due to its phytochemicals and possibly human health advantages, black cumin continues to attract a lot of study attention. Despite these advantages, little research has been done on its response to irrigation. Black cumin could resist water deficiency, according to Bannayan et al. (2008) and Ghamarnia et al. (2010); nevertheless, Ghamarnia and Jalili (2013) claimed that black cumin was vulnerable to water stress. According to the literature review, there have also been no investigations on this crop's response to thinning. These seemingly incongruent results encouraged us to research to establish the most effective plant population and watering schedule for improving black cumin growth, quality and output.

II. Materials and Methods

The experiment was conducted at the Spices Research Sub-Centre, Bangladesh Agricultural Research Institute (BARI), Lalmonirhat, during 2019-2020. The geographical location of the station is 25.33^0 North latitude and 87.1^0 east longitude with an elevation of 32.2 m from the sea level (Mondal, 2006). The experiment was laid out in randomized complete block design, having three replications. The treatments comprised four thinning levels and three irrigation regimes, which were as follows:

T_1=1st thinning at 25 days after sowing
T_2=2nd thinning at 35 days after sowing
T_3=3rd thinning at 45 days after sowing
T_4= control (no thinning)

I_1= vegetative stage + flowering stage
I_2= Vegetative stage + capsule stage
I_3= Vegetative stage + flowering stage + capsule stage

The total number of unit plots was 36 and the unit plot size was 2m × 1.2m. All plot received cow-dung @ 3 t ha^{-1} and N_{58}, P_{43}, K_{46} S_{20} kg/ha. The entire quantity of cowdung, P, K, S and ½ N will be applied during final land preparation and the rest of N will be applied in two equal splits at 20-40 days after sowing. Seeds of black cumin with seed rate @ 6 kg/ha were sowed on November 10, 2019 with a distance of 30 cm between row to row in continuous sowing in rows. Intercultural operation was done as and when necessary, but only irrigation and thinning were applied as per treatment. After thinning plants were arranged in range about 1-3cm as per treatment. Application of Atistin @2g/leter and Amistertop @2g/liter were done at 25 days and 65 days of plants, respectively and plants harvested on March 30, 2019. Data on plant population/linear meter, plant height (cm), number of branching/plant, number of capsules/plant, number of seeds/capsule, thousand seed weight (g), germination percentage and seed yield (t/ha) were collected. The collected data were statistically analyzed and the mean differences were tested by the Least Significant Difference (Gomez and Gomez, 1984).

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III. Results and Discussion

Effect of thinning

The variations due to different thinning under the study were significant in respect of all parameters except plant height (cm) (Table 01). It was observed that T_2 and T_3 thinning levels responded to the highest performance in respect of yield components followed by T_1 and T_4 thinning levels and also highest yield was obtained from T_4 thinning (Figure 01). It may be accounted due to optimum plant population receiving nutrient, moisture and favors to air–temperature resulting in better growth and development of the plants. Similar result was made by (Sadeghi et al., 2009). The maximum thousand seed weight (3.10 g) was recorded from T_2 (Figure 02), while the minimum was in T_4. The maximum seed yield (1.130 t/ha) was recorded from the T_4 due to maximum number of plant populations which is statistically similar to T_1 and T_2 while the minimum was found in T_3 (Figure 03). In the study T_2 treatment received optimum plant population (110.33) that lead to maximum number of branching/plant, capsules/plant, seeds/capsules and germination percentage and thousand seed weight.

Table 01. Effect of thinning on the yield component of black cumin

Treatment	Plant height (cm)	No. of branches/plant	No. of capsules/plant	No. of seeds/capsule	Germination (%)
T_1= 1st thinning (25 DAS)	60.68a	4.63b	17..43b	67.39b	88.41ab
T_2= 2nd thinning (35 DAS)	62.49a	6.31a	21.91a	74.63a	94.30a
T_3= 3rd thinning (45 Das)	61.44a	4.69b	20.02ab	71.64ab	93.26a
T_4= no thinning	56.78a	4.55b	16.0b	65.47b	84.45b
Level of sig.	NS	*	*		*
CV (%)	8.11	10.54	12.21	14.45	11.23

*= 5% level of probability; NS= Non-significant

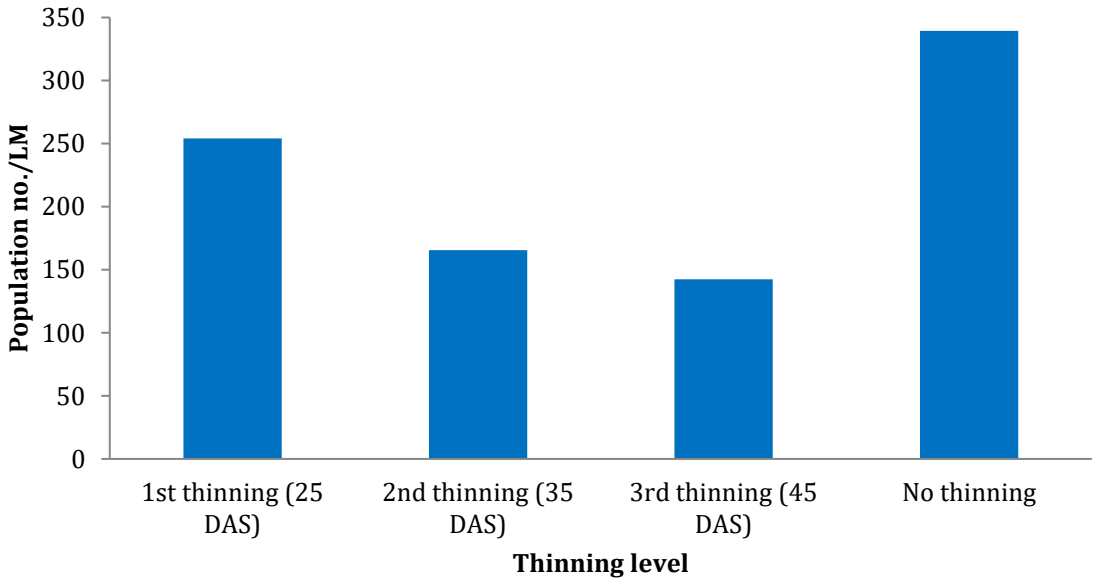

Figure 01. Effect of thinning on the plant populations under field conditions.

Effect of irrigation on morphological traits and yield components

Irrigation schedule showed non-significant effect on the yield components, thousand grain weight and germination percentage except plant height, number of branching and seed yield (Table 02 and Table 03). In black cumin, fruit is a large and inflated capsule containing numerous seeds. Therefore, capsule number per plant is considered a critical yield component. In our study, the effect of irrigation levels was non-significant. The highest number of capsules per plant (21.23) was achieved with full irrigation, whereas the lowest value (19.54) was obtained from I_2. Our findings were similar to a previous study by Bannayan et al. (2008), who reported that a decrease in capsule number was observed with increased water stress in black cumin.

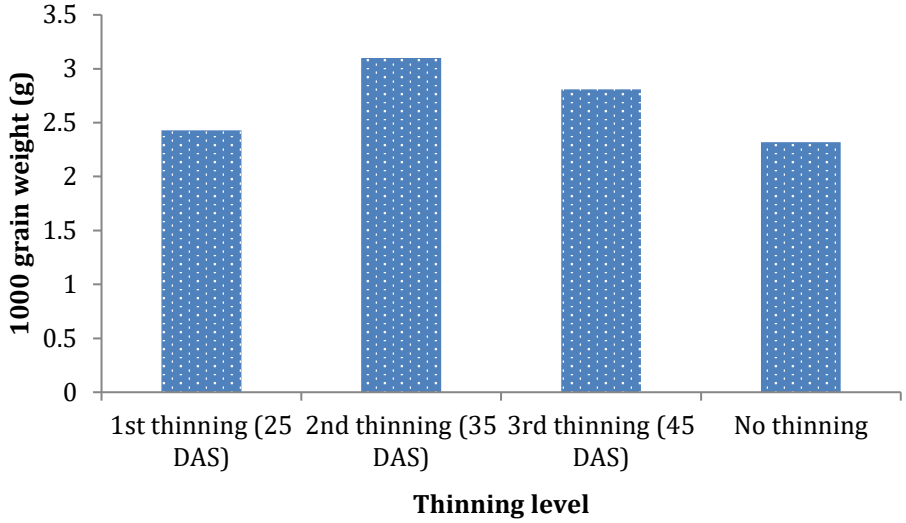

Figure 02. Effect of thinning on the thousand seed weight and yield.

Average plant heights of black cumin plants grown under different irrigation levels were given in Table 02. There were significantly different irrigation levels on plant height. Increase in water deficit consistently and significantly reduced plant heights of black cumin plants. Indeed, this finding is not surprising, considering drought stress during the vegetative growth stage affects cell division and elongation, reducing plant height (Litvin et al., 2016). Similar findings were reported by Ghamarnia et al. (2010), who stated that black cumin plants differed in their response under different irrigation levels and plant height of black cumin decreased with increased water deficit.

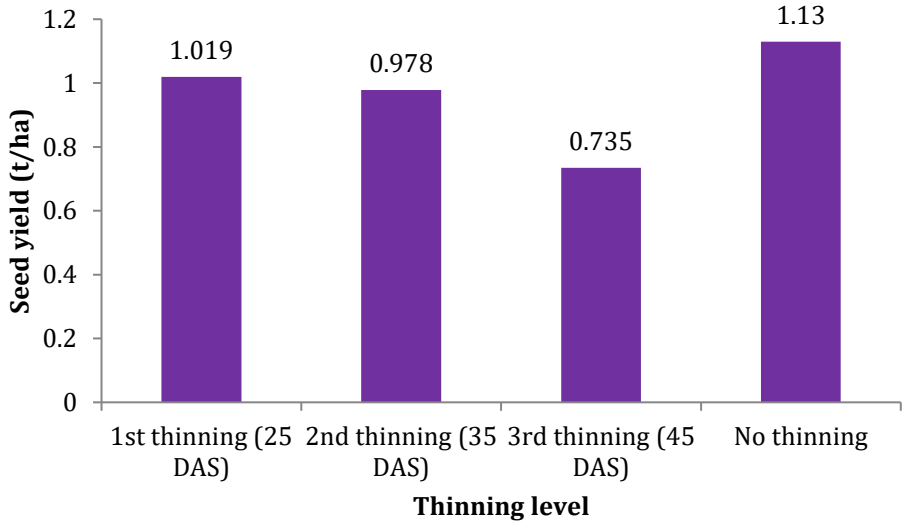

Figure 03. Effect of thinning on the seed yield.

Due to the effect of irrigation, the number of branches per plant was significantly different in black cumin (Table 01). The maximum number of branches (5.48) was recorded in I_1. The second highest number of branches was recorded in I_2 (4.92), which was statistically similar to I_3 (3.82). The number of branches on black cumin plants continuously dropped as irrigation quantities were reduced, similar to plant height. The findings are consistent with previous research that found that as water deficit treatment increased, the number of branches per plant reduced in rapeseed (Moghadam et al., 2011). Better branch number is a favourable characteristic in crop plants because genotypes with more branches may have a higher seed yield per plant (Wu et al., 2015).

Plant growth received suitable moisture in respect of I_1 which is statistically similar to I_2. Consequently, the maximum seed yield was obtained from I_1 treatment. However, black cumin is sensitive to excessive soil moisture for growth and development, leading to yowling and stunted growth and ultimately plant drying to death. Therefore, suitable irrigation is needed at the developmental stage of black cumin, especially in the vegetative and flowering stages. This finding is connected to Karim et al. (2017).

Table 02. Effect of irrigation on the yield component and yield of black cumin

Treatment (Irrigation stage)	Plant height (cm)	No. of branches /plant	No. of capsules /plant	No. of seeds/ capsule	1000 seed weight (g)	Germination (%)	Seed yield (t/ha)
I_1 (Vegetative+ lowering stage)	63.36a	5.48a	20.32a	63.40a	2.32a	90.31a	1.005a
I_2 (Vegetative+ Capsule stage)	58.39b	4.92b	19.54a	64.44a	2.28a	89.12a	0.865ab
I_3 (Vegetative+ Flowering+ Capsule stage)	61.43ab	3.82ab	21.23a	63.78a	2.11a	89.0a	0.779b
Level of significance	*	*	NS	NS	NS	NS	*
CV (%)	8.11	10.54	12.21	14.45	10.07	11.23	9.22

NS= Non-significant, *= 5% level of significance

Table 03. Effect of irrigation on the plant populations of black cumin

Treatment (Irrigation stage)	Population no. after 1st thinning	Population no. after 2nd thinning	Population no. after 3rd thinning
I_1 (Vegetative+ Flowering Stage)	260.0a	168.50a	132.52a
I_2 (Vegetative+ Capsule Stage)	255.37a	165.45a	137.30a
I_3 (Vegetative+ Flowering+ Capsule Stage)	253.36a	167.60a	130.42a
Level of significance	NS	NS	NS
CV (%)	9.12	8.10	6.45

Interaction effect

The combined effect of thinning and irrigation regimes showed a significant variation in all studied parameters. In the study, the combination of T_4I_1 treatment gave the highest yield (1.211 t/ha) due to the higher population, which was statistically similar to the T_2I_1 treatment combination due to optimum plant population. The optimum plant population responded to better performance regarding yield component and quality (TGW and germination percentage) parameter (Table 04).

Table 04. Interaction effect of thinning and irrigation regimes on the yield component, quality and yield of black cumin

Treatment (Thinning × Irrigation)	Plant height (cm)	No. of branches/ plant	No. of capsules/ plant	No. of seeds/ capsule	TGW (g)	Germination (%)	Seed yield (t/ha)
T_1I_1	59.44ab	4.40abc	18.47bc	67.43cd	2.70ab	89.36abc	0.877abc
T_1I_2	58.21abc	3.47c	18.69bc	66.67de	2.68ab	88.56abc	0.88abc
T_1I_3	60.43ab	4.63ab	19.45abc	67.48cd	2.74ab	89.0abc	0.792abc
T_2I_1	60.23ab	5.96a	22.38a	75.30a	3.0a	92.28a	1.033a
T_2I_2	57.05bc	4.60ab	20.35ab	73.22ab	2.78ab	90.34ab	0.921ab
T_2I_3	60.49a	4.40abc	20.63ab	73.78ab	2.80ab	91.30ab	0.932ab
T_3I_1	61.72a	4.83ab	21.31ab	71.24b	2.79ab	91.0ab	0.697bc
T_3I_2	60.44ab	4.11abc	20.04ab	71.72b	2.81ab	91.32ab	0.689bc
T_3I_3	59.33ab	4.54ab	19.68abc	70.33b	2.83ab	90.61ab	0.678c
T_4I_1	57.34bc	4.0abc	16.37c	62.20e	2.42b	85.21bc	1.211a
T_4I_2	56.65c	3.86bc	17.83bc	61.54e	2.38b	84.52bc	1.143a
T_4I_3	58.31abc	4.22abc	17.11bc	59.63f	2.24b	84.33c	1.008a
Level of sig.	*	*	*	*	*	*	*
CV (%)	8.11	10.54	12.21	14.45	10.07	11.23	9.22

NS= Non-significant, *= 5% level of significance

IV. Conclusion

The effects of four thinning types and three different irrigation levels on yield and yield components of black cumin were evaluated. Results indicated optimum plant population and irrigation at different

stages of black cumin plant during growing period favours better growth and development. So, the two thinning at 25 & 35 DAS and two irrigation at vegetative and flowering stage treatment combination may successfully cultivate black cumin.

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