Effect of Irrigation Levels on Yield Performance of Black Cumin

Karim M.[1*], R.M. Himel[2], J. Ferdush[3], M. Zakaria[4]

[1*]Corresponding author, Department of Horticulture, Bangabandhu Sheikh MujiburRahmanAgricultural University, Bangladesh, Gazipur. E-mail: karimmeftahul@gmail.com Tel: +8801725435158
[2] Scientific Officer, Bangladesh Tea Research Institute, Srimongol, Bangladesh
[3] Scientific Officer, Bangladesh Jute Research Institute, Dhaka, Bangladesh
[4]Professor, Department of Horticulture, Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur, Bangladesh.

Abstract— *An experiment was conducted in the experimental field of Horticulture Department, Bangabandhu Sheikh MujiburRahman Agricultural University (BSMRAU), Salna, Gazipur during the period from 20 November, 2012 to 12 April, 2013 to determine the optimum level of irrigation for better yield and quality of black cumin. There were six different irrigation levels (I_1 - no irrigation, I_2 - three irrigation, I_3 - four irrigation, I_4 - six irrigation, I_5 - eight irrigation and I_6 - ten irrigation). Results revealed that the number of primary branches (6.33), secondary branches (11.84), tertiary branches (6.29), number of capsule per plant (18.64), capsule length (1.89 cm), diameter of capsule(1.05 cm), number of seed per capsule (107.8), fresh seed yield per plant (3.84g), dry seed yield per plant (3.26g), 1000 seed weight (2.40g) and seed yield (1.77 t/ha) were observed maximum in I_6(ten irrigation).*

Keywords— Black cumin, capsule, irrigation, seed, yield.

I. INTRODUCTION

Black cumin (*Nigella sativa* L.) is an annual aromatic plant native to Southwest Asia and the Mediterranean region. Presently, it is cultivated in various parts of the world, including Asia, the Middle East and North Africa. Seed of black cumin contain about 21% protein, 35% carbohydrates and 35-38% plant fats and oils [1]. It contains all essential amino acids and rich source of vitamins and minerals [2, 3]. Total cultivable area of Bangladesh is 14.86 million hectare but only 56 percent of cultivable area under irrigation coverage [4]. North-west part of the country mostly is affected by the droughts which generally has lower rainfall than the rest part of the country. Crop production will become impossible especially in drier northern and western regions of the country. The cost of irrigation is one the main obstacle for small farming. Optimizing irrigation management together with the cultivation of appropriate crops is desirable in these regions [5]. The total annual production of black cumin is 3675 tons from 3530 hectares of land with an average yield of 1.04 t/ha [6]. The yield is low compared to Iran(1.71- 2.1 t/ha)[7]. In farmers field of some places of Bangladesh, yield is 1.19 to 1.48 t/ha [8]. Black cumin is an annual plant, originally grown in arid and semi-arid regions[9]. One third of the world lands are classified as arid and semi-arid region and the remains are faced with water seasonal or local fluctuations[10]. Availability of water rather than land is the main constraint on agricultural production in arid and semi-arid environments [11]. Some studies shown that, the black cumin is able to tolerate moderatelevels of water stress [11, 12].Some researchers have focused on response of black cumin to different irrigation intervals [12, 13] and irrigation scheduling based on developmental stage [11]. Moreover, deficit irrigation is one way of maximizing water use efficiency (WUE) for higher yields per unit of irrigation water applied where crop is exposed to a certain level of water stress either during a particular period or throughout the entire growing season [14]. The cost of irrigation pumping and inadequate irrigation capacity as well as limited water sources is among the reasons that force many farmers in the region to reduce their irrigation applications. Irrigation scheduling based on developmental stage is the technique of applying water on a timely and accurate basis to the crop [15]. Irrigation cost in Bangladesh is 4 times higher than India, 6 times thanThailand and Vietnam. High irrigation cost in Bangladesh is one of the major obstacles for crop production. Considering the above facts the experiment was undertaken to determine optimum level of irrigation for obtaining better yield of black cumin.

II. MATERIALS AND METHODS

The experiment was conducted at the Horticultural Research Farm of Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur during the period from 20 November, 2012 to 12 April, 2013. The experimental site was located at the Centre of Madhupur Tract $24^0 09'$ N latitude and $90^0 26'$ E longitudes at 8.5 meter above the sea level and about 40 km north of Dhaka.

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2.1. Treatments of the experiment:

The experiment consisted of six treatments: I_1 = No irrigation I_2 = Three irrigationI_3 = Four irrigation I_4 = Six irrigation I_5 = Eight irrigation I_6 = Ten irrigation

2.2 Design and layout:

The field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was divided into three blocks which represented replication. The treatments were randomly allotted in each replication.

2.3**.** Plant material:

Exotic variety of black cumin was used as plant material.

2.4. Collection of data:

Data were collected from the inner rows of each plot to avoid the border effect. The following seed yield and yield contributing parameters were observed.

2.5. Number of branches per plant:

The primary, secondary and tertiary branches per plant were counted at the time of harvesting. Ten randomly selected plants from each plot were used for counting number of primary, secondary and tertiary branches.

2.6. Length of capsule:

A slide calipers was used to measure the capsule length in centimeter. Ten randomly selected capsules were taken from each plot to take average length of capsule.

2.7. Capsule diameter:

A slide calipers was used to measure the capsule diameter in centimeter. Ten randomly selected capsules were taken from each plot to measure average diameter of capsule.

2.8. Number of seeds per capsule:

Ten randomly selected capsules were taken from each plot and average seeds per capsule were counted.

2.9. Number of capsule per plant:

Ten randomly selected plants were taken from each plot and average capsules per plant were counted.

2.10. Fresh seed yield per plant:

Fresh seed yield per plant was calculated from the total fresh weight of seed often randomly selected plants dividing by ten.

2.11. Dry seed yield per plant:

Dry seed yield per plant was calculated from the total sundried weight of 10 randomly selected plants dividing by ten. Moisture content of seed was about 10%.

2.12. 1000 seed weight:

Thousand seeds of randomly selected 10 samples were weighted and its averages were taken with the help of an electric balance.

2.13. Seed yield:

The mature seeds of all plots were harvested, cleaned and dried. First plot yield was obtained in kg by the help of electric balance. Then plot yield was converted into t/ha.

2.14. Statistical analysis:

The recoded data on different parameters were statistically analyzed and partitioning the variance with the help of "MSTAT-C" software. The difference between treatment means was compared by Duncan's Multiple Range Test (DMRT).

III. RESULT AND DISCUSSION

3.1. Number of branches per plant:

Due to effect of irrigation, the number of primary branches found significantly different in black cumin (Fig. 1). The maximum number of primary branches (6.33) was recorded in I_6 (Ten irrigation) which was statistically similar to I_5 and I_4 while the minimum number of primary branches (4.92) was observed in I_1. The effect of irrigation on the number of secondary branches found significant (Fig. 1). The maximum number of secondary branches (11.82) was recorded in I_6 which was statistically similar to I_5, I_4 and I_3. The minimum number of secondary branches (5.87) was observed in $I_{1.}$The effect of irrigation on the number of tertiary branches also found significant (Fig.1). The plants irrigated ten times (I_6) produced the highest number of tertiary branches (6.26) and the lowest number of tertiary branches (0.16) was observed in I_1(No irrigation). The number of primary, secondary and tertiary branches increased with the increasing number of irrigation.These results may be due to the effect of short watering intervals, plants received sufficient moisture to enhance the rates of physiological processes and increasing the hydrostatic pressure on the cell wall, which is necessary for the enlargement of cell.Hence, enhancement of the assimilated food and increase the cell elongation and division consequently, the whole growth of plant as well as branching could be increased [16].

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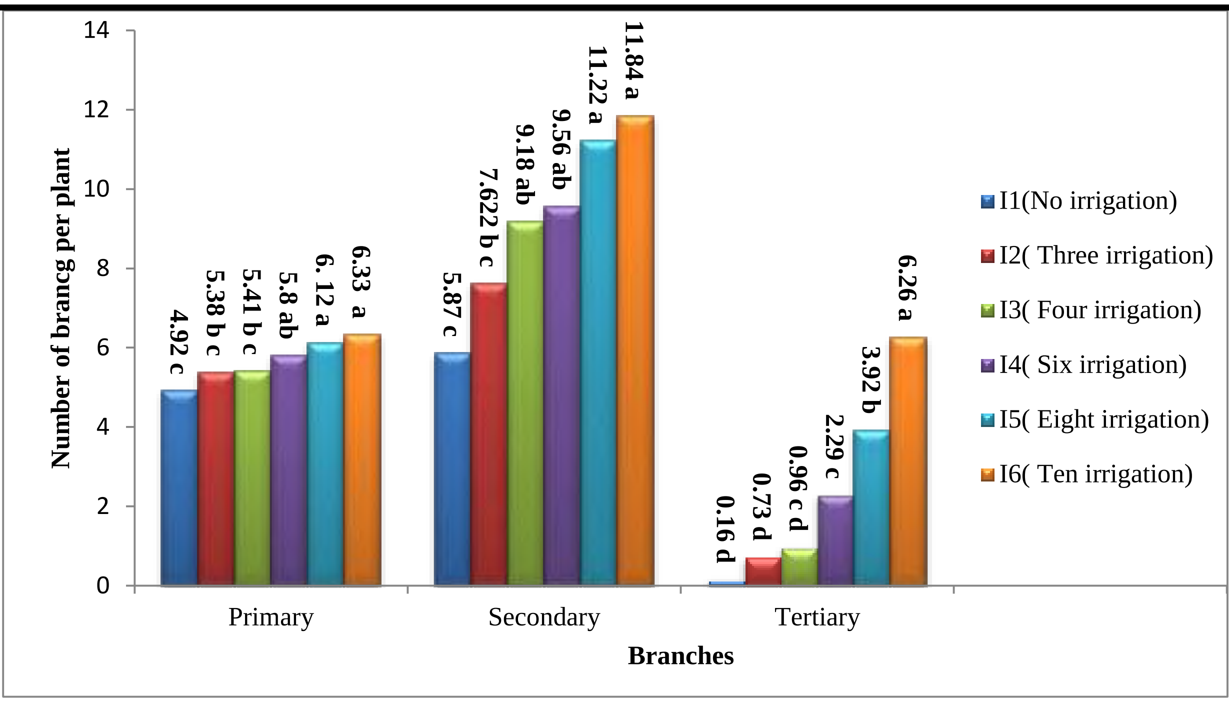

Fig.1: Effect of irrigation on the number of branches per plant.

3.2. Length & diameter of capsule:

The effect of irrigation on the length of capsule was found significant (Table 1). The maximum capsule length (1.89cm) was recorded in I_6 which was statistically similar to I_5 and I_4. The minimum capsule length (1.13cm) was observed in I_1 (No irrigation) which was statistically similar to all except I_6.

The effect of irrigation on the diameter of capsule was found significant (Table 1). The maximum capsule diameter (1.05cm) was recorded in I_6 which was statistically similar to I_5, I_4 and I_3. The minimum capsule diameter (0.78cm) was observed in I_1 which was similar to I_2, I_3 and I_4. The diameter of capsule increased with the increasing of irrigation number.

3.3. No. of capsule per plant & no. of seed per capsule:

The effect of irrigation on the number of capsule per plant was also found significant (Table 1). The highest number of capsule (18.64) was observed in I_6 (Ten irrigation) which was statistically different from others. The lowest number of capsule (10.42) was found in I_1 which was statistically at par with I_2 and I_3. Number of capsule increased with the increasing number of irrigation. The higher number of irrigation facilitated the plant to produce more branches resulting more capsules per plant.

The effect of irrigation on the number of seed also found significant (Table 1).The plants treated with I_6 produced maximum number of seed (107.8) closely followed by I_5 (97.48). The minimum number of seed (81.77) was observed in I_2 which wasstatistically identical to I_1 (87.07), I_3 (84.62) and I_4 (85.81). The number of seed increased with the increasing of irrigation. Due to less irrigation during the growing period caused a decrease of water use efficiency, biomass and number of seeds. And drought that occurred in the late growing season affected seed filling. Decrease in number of seeds per capsule and seeds per plant in water stress conditions can be the result of water shortage during the seed filling stage that shortens the flowering [17]. Irrigation had a significant effect on number of follicles per plant [11].

Table. 1: Effect of irrigation on capsule length, diameter, number of capsule per plant and seed per capsule in black cumin.

Irrigation frequency	Capsule length(cm)	Capsule diameter	No. of capsule per plant	No. of seed percapsule
I_1-No irrigation	1.09 b	0.78 b	10.42 d	87.07 c
I_2- Three irrigation	1.13 b	0.84 b	10.61 d	81.77 c
I_3- Four irrigation	1.21 b	0.91 ab	11.99 cd	84.62 c
I_4- Six irrigation	1.30 ab	0.92 ab	13.52 c	85.81 c
I_5- Eight irrigation	1.42 ab	1.04 a	16.11 b	97.48 b
I_6- Ten irrigation	1.89 a	1.05 a	18.64 a	107.8 a
Level of significance	*	*	*	*
CV%	7.70	9.88	9.16	6.08

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

3.4. Fresh and dry seed yield per plant (g)

Fresh seed yield per plant is an important yield contributing character varied significantly due to different genotypes. The effect of irrigation on fresh seed yield per plant was found significant (Fig.2). The plants irrigated ten times (I_6) showed maximum fresh seed yield (3.84g) which was statistically identical to I_5 (3.53g). The minimum fresh seed yield (1.86g) was observed in I_1 which was statistically similar to I_2. The supply of sufficient water from the soil due to more irrigation might have helped in maintaining better substrate for photosynthetic activities in the leaves. It is well known fact that proper supply of moisture help in maintaining high photosynthetic rate and turgidity, which could increase the cell elongation and its multiplication at much faster rate resulting higher seed yield per plant.

The effect of irrigation on dry seed yield per plant was also found significant (Fig.2). The maximum dry seed yield (3.26g) was recorded in I_6 which was statistically similar to I_5 (3.00g). The minimum dry seed yield (1.45g) was observed in I_1 which was statistically identical to I_2.

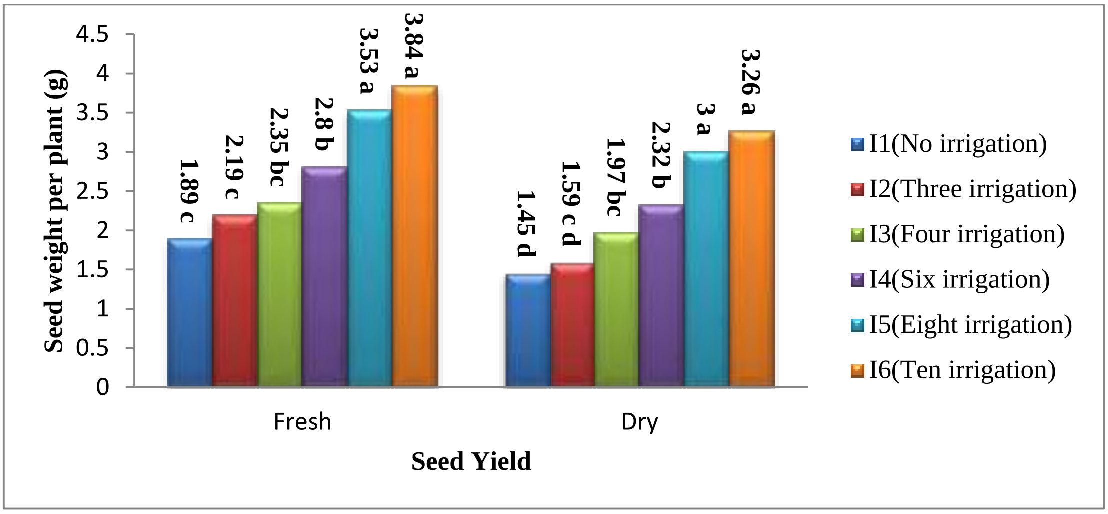

Fig. 2: Effect of irrigation on fresh & dry seed yield per plant.

3.5. 1000 seed weight (g)

Thousand seed weight is an important yield contributing character. The effect of irrigation on 1000 seed weight was found significant (Fig. 3). The maximum 1000 seed weight (2.40g) was recorded in I_6 (Ten irrigation) which was statistically similar to I_5 (2.31g) and the minimum 1000 seed weight (1.85g) was observed in I_1 (No irrigation). The results were similar to those of [11, 18] where significant difference in 1000 seed weight was reported in different irrigation treatments for black cumin.

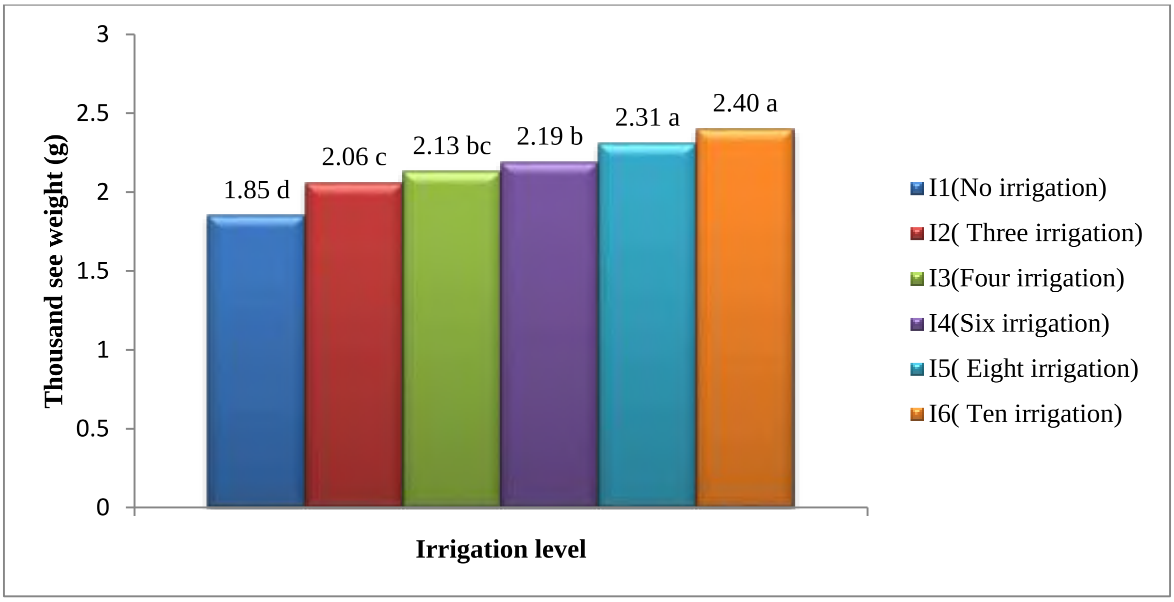

Fig.3: Effect of irrigation on 1000 seed weight.

3.6. Seed Yield

Seed yield per hectare varied significantly due to influence of irrigation (Fig. 4). The highest seed yield (1.77 t/ha) was found in I_6 (Ten irrigation) which was statistically different from others. The minimum seed yield (1.31 t/ha) was observed in I_1 (No irrigation). Reduced yield as impact of stress mainly is due to shortening of plant growth stages [17]. Yield of black cumin per hectare increased with increase of irrigation which was similar to results obtained by [19, 20, 21, and 22]. All of them reported to have an increasing yield with increase in irrigation water supplied. The yield and growth characters were maximum at 0.8 IW/CPE (fiveirrigation) [23]. It was due to higher physiological activities favoring higher nutrient uptake and photosynthesis which might be responsible for formation of more photosynthesis under this treatment resulting more yields. Besides, improvement in physical, chemical and microbial environment of soil, it might have also increased the availability of nutrients and water. The supply of sufficient water from the soil might have helped in maintaining better substrate for photosynthetic activities in the leaves. It is well known fact that proper supply of moisture help in maintaining high photosynthetic rate and turgidity, which could increase the cell elongation and its multiplication at much faster rate. Drought stress made changes in photosynthetic pigments and components [24] damaged photosynthetic apparatus [25] and diminished activities of Calvin cycle enzymes, which are important causes of reduced crop yield.

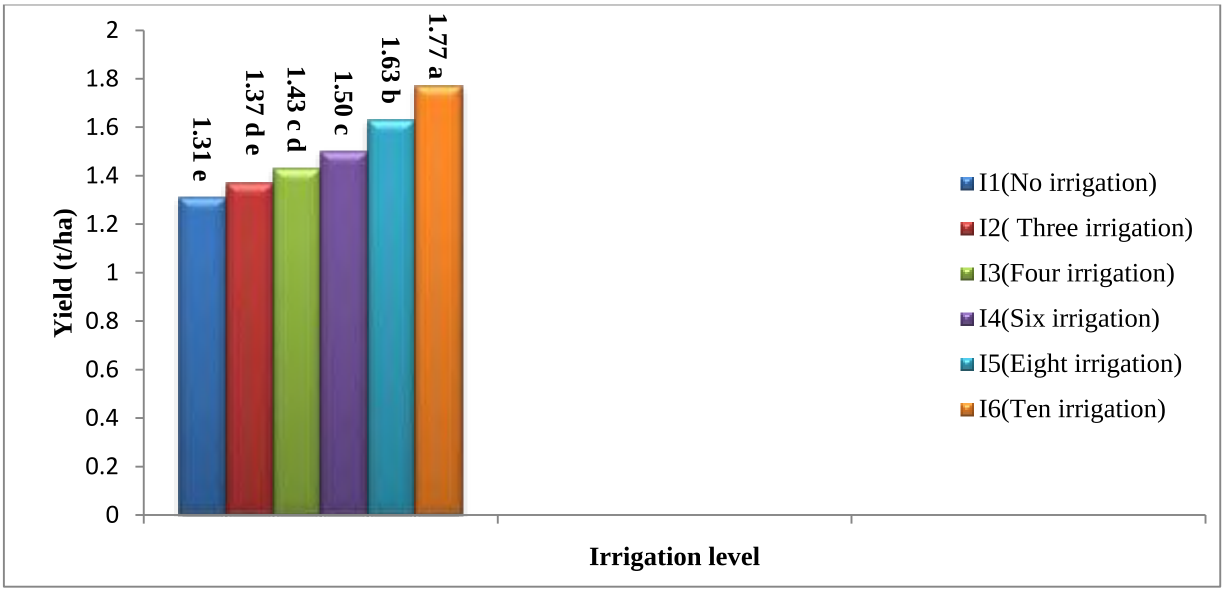

Fig. 4: Effect of irrigation level on seed yield.

The result revealed that almost all the parameters studied significantly influenced by different level of irrigation, the highest primary branches (6.33), secondary branches (11.84), tertiary branches (6.26) at 75 DAS were found in I_6 (Ten irrigation) and lowest was found in I_1 (No irrigation).

The maximum capsule length (1.89 cm), capsule diameter (1.05 cm), number of capsule per plant (18.64), number of seed per capsule (107.8), fresh seed yield per plant (3.84g) and dry seed yield per plant (3.26g) were found in I_6 (Ten irrigation).

1000 seed weight and seed yield were maximum (2.40g and 1.77 t/ha respectively) in I_6 (Ten irrigation).

IV. CONCLUSIONS AND RECOMMENDATIONS

The plants received higher number of irrigation I_6 (Ten irrigation) produced maximum number of primary branches, number of secondary branches, number of tertiary branches, capsule length, capsule diameter, number of capsule per plant, number of seed per capsule and seed yield per hectare. Similar type of experiment may be conducted in different Agro-Ecological Zones (AEZs) to confirm the results.

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