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Effect of different fertilizer levels on yield performance of black cumin in Brahmaputra and Jamuna floodplain soil of Bangladesh

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ABSTRACT

Although black cumin is an important spice and medical crop, the average yield is low in Bangladesh. The imbalance of fertilizer and local cultivar use are the major causes of the low yield of black cumin. Therefore, an attempt was made to develop and evaluate the performances of different fertilizer doses (in terms of crop productivity and economic performance) for improved varieties of black cumin in the farmers' field at the Multi Location Testing site, Bhuapur, Tangail in 2017-18 and 2018-19. Treatment included Soil Test Based fertilizer dose - STB (106-32-30-12-2-1 kg NPKSZnB ha^{-1}) as per Fertilizer Recommendation Guide, 2012, STB + 15% extra NPK (122-37-35-12-2-1 kg NPKSZnB ha^{-1}), STB + 30% extra NPK (138-42-39-12-2-1 kg NPKSZnB ha^{-1}) and Farmer's practice (35-15-19 kg NPK ha^{-1}) and two varieties of black cumin namely V_1 = BARI Kalozira-1 and V_2 = Local. The experiment was conducted in a Randomized Complete Block Design with six replications. Among the treatment combinations, the highest average seed yield (1.24 t ha^{-1}) and gross margin (Tk. 130179 ha^{-1}), along with BCR (2.74), were obtained from STB with BARI Kalozira-1. The lowest average seed yield (0.54 t ha^{-1}) and gross margin (Tk. 24414 ha^{-1}), along with BCR (1.38), was recorded from a local variety with farmer's practiced fertilizer dose.

***Key Words**: Fertilizer dose, Black cumin, Charland, Soil test-based fertilizer dose and BARI Kalozira-1.*

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I. Introduction

Black cumin (*Nigella sativa* L.) is a short-lived, hardy annual herb belonging to the family Ranunculaceae (diploid, 2n=12). Due to having unique aromatic and medicinal properties, black cumin seeds and oil have high commercial potential as spices medicine. It is used in the kitchen, pickles and seasoning of many backer products. The whole seeds or their extracts are commonly used to treat

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intestinal worms and are believed to relieve digestive troubles. The seeds and oil are also used for inflammation to reduce bronchitis symptoms and asthma and treat rheumatoid arthritis (Petruzzello, 2018). Black cumin seeds showed 20.3% crude protein, 45.4% crude fat, 7.1% moisture, 7.4% ash, 19.7% total carbohydrate and 92.9% dry matter (Kabir et al., 2019). Black cumin is resumed to originated in the Mediterranean region. It is widely cultivated in North Africa, South Europe, Middle East, China, Japan, Turkey, Iran and Indian Sub-continent (Rana et al., 2012; Bhutia et al., 2015).

In Bangladesh, black cumin is an important essential spice called 'Kalozira'. The total production of black cumin in Bangladesh is 1005 million tons from 862 ha of land (BBS, 2021), mainly in the districts of Bogura, Sariatpur, Faridpur, Madaripur, Pabna, Sirajganj, Jessore, Kustia, Rangpur and Natore (Ali et al., 2015b; Noor et al., 2008). However, the average yield of black cumin is low in Bangladesh due to diseases and insect infestation, imbalance fertilization, poor agronomic practices and use of local cultivars (Bhutia et al., 2015). Therefore, there is a need to improve the yield and quality of black cumin by adopting suitable varieties and fertilizer management practices.

The Spices Research Centre of Bangladesh Agricultural Research Institute has released a high yielding black cumin variety named 'BARI Kalozira-1', suitable for cultivation all over Bangladesh in the Rabi season. This variety has higher yield potential, better quality traits and resistance to diseases than the local variety (Ali et al., 2015a). Applying NPK fertilizer increases the yield of black cumin (Al-Saadi and Alhalabi, 2012). The application of N and P @ 60 and 120 kg ha^{-1} provides the maximum growth, yield and quality of black cumin (Rana et al., 2012). In the Gangetic alluvial plains, NAA at 100 ppm with N-P-K @30-40-45 kg ha^{-1} and farm yard manure (FYM) @15 t ha^{-1} application increased the seed yield of black cumin. The dry matter weight, number of primary branches, number of capsules and 1000-seed yield of different black cumin varieties were significantly influenced by different levels of NPK fertilizers (Ali et al., 2015a).

Black cumin is cultivated in the Charlands of Bhuapur upazila in the Tangail district of Bangladesh without proper fertilizer management. The Bhuapur Upazila of Tangail district has about 12841 ha of Charland (SRDI, 2017), whereas the total Charland of Bangladesh is 0.82 million ha (EGIS, 2000). They also use local indigenous variety, which provides poor yield and are susceptible to different types of pest. Spices Research Centre of Bangladesh Agricultural Research Institute has released a high yielding black cumin variety named 'BARI Kalozira-1', which is suitable for cultivation all over Bangladesh in the Rabi season. Char areas have enough scope for large scale black cumin production following proper and suitable fertilizer management along with yielding variety. The present study was therefore undertaken to determine the optimum fertilizer dose of black cumin in char areas under AEZ 8 (Young Brahmaputra and Jamuna Floodplain) soil. The objectives of the study were:

- To evaluate the effects of different fertilizer doses and variety on growth, yield and quality of black cumin in char areas.
- To determine the optimum fertilizer dose for black cumin cultivation in char areas.
- To estimate the cost and return analysis of black cumin production under different fertilizer doses and variety in char areas.

II. Materials and Methods

Site selection

The experiment was conducted at the Multi-Location Testing (MLT) site, Bhuapur, Tangail, of the On-Farm Research Division, Bangladesh Agricultural Research Institute, Tangail, under Agro-Ecological Zone -8 during the two consecutive cool dry season seasons of 2017-18 and 2018-19. The geographic coordinates of the experimental location were 24°29/N, 89°50/E and 15 m above sea level. Before conducting the experiment, initial soil samples were collected at 0-20 cm soil depth from the experimental plot and collected samples were analyzed for determination of soil nutrients. The soil chemical characteristics of the experimental plot are presented in Table 01.

Weather data

The maximum, minimum temperature (°C) and total rainfall (mm) of the experimental field are presented in Figure 01 (BMD, 2019). The highest rainfall (576.1 mm) occurred in July, 2019 whereas no rainfall was recorded in January & February, 2017; January, 2018 and January, 2019. The mean maximum temperature (34.79°C) was recorded in May, 2019 and minimum temperature (11.57°C) in January, 2019.

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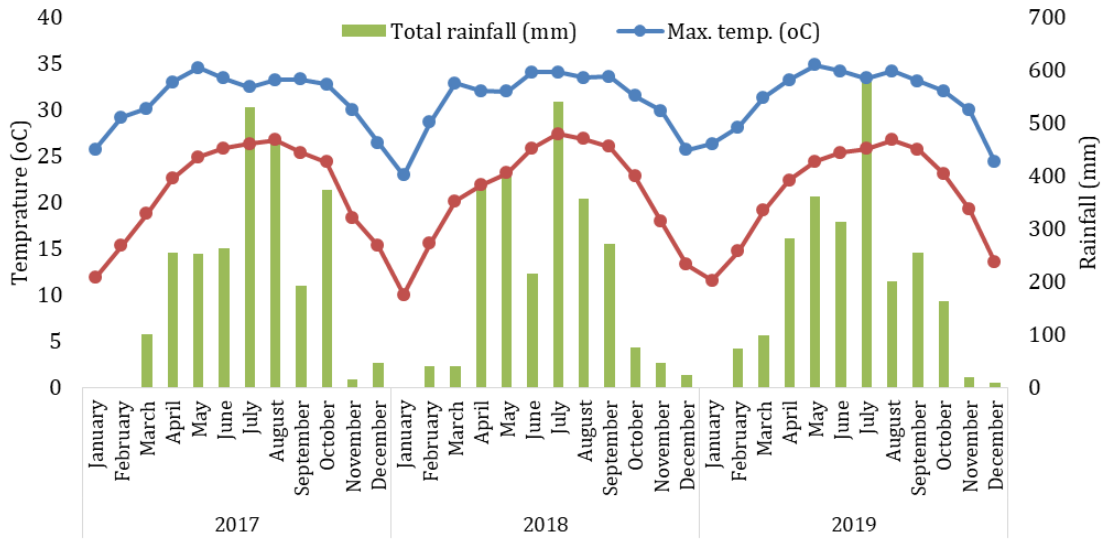

Figure 01. Maximum, minimum temperature (°C) and total rainfall (mm) during 2017-18 and 2018-19 at MLT site, Bhuapur, Tangail

Land preparation

The experimental location was prepared one month before transplanting. The total amount of phosphorus, potassium, sulfur, zinc and boron was applied during the final land preparation. Nitrogen was divided into two equal splits and applied as top-dressing at 35 and 55 days after sowing (FRG, 2012).

Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with four fertilizer doses and two black cumin varieties with six replications. The unit plot size was 5 m x 4 m.

Plant materials

Seeds of black cumin variety BARI Kalozira-1 were collected from Spices Research Centre, BARI, Gazipur and the seeds of the local variety of black cumin were collected from local farmers of Bhuapur, Tangail. Initial moisture contents of black cumin seeds were 11%.

Treatment details

Four fertilizer doses viz. T_1: Soil Test Based fertilizer dose (STB) (106-32-30-12-2-1 kg NPKSZnB ha^{-1}) as par Fertilizer Recommendation Guide (FRG, 2012), T_2: STB + 15% Extra NPK (122-37-35-12-2-1 kg NPKSZnB ha^{-1}), T_3: STB + 30% Extra NPK (138-42-39-12-2-1 kg NPKSZnB ha^{-1}) and T_4: Farmers practice (35-15-19 kg NPK ha^{-1}) and two black cumin variety (V_1: BARI Kalozira-1 and V_2: Local) were considered. The general fertilizer dose for black cumin practiced by ten farmers was averaged to determine the farmers' practice fertilizer dose. The seeds of black cumin were sown, maintaining a 15 cm line to line distance with continuous sowing.

Table 01. Chemical properties of the experimental soil (initial soil) sample

	pH	OM (%)	N (%)	P (µg/g)	K (meq/100g)	S (µg/g)	Zn (µg/g)	B (µg/g)
Soil test value	6.97	1.48	0.067	4.39	0.181	15.46	0.49	0.248
Interpretation	-	-	Very low	Very low	Medium	Medium	Low	Low

Intercultural operation

The seeds were sown in the experimental plot by hand on 23 November 2017 and 13 November 2018 following the 8 kg ha^{-1} seed rate (Azad et al., 2017; Yousuf et al., 2018). Seeds of black cumin were soaked in water for 24 hours before sowing to enhance germination. After soaking, the seeds were air-dried and treated with carbendazim group fungicide @ 2 g kg^{-1} seeds to minimize the seed-borne diseases. The seeds were mixed with some loose soil to ensure uniform sowing (Yousuf et al., 2018). Intercultural operations (two weeding, two irrigations) were done for the proper growth and development of crops.

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Measurement of yield and yield attributes

In this study plant height (cm), the number of the capsule (capsule plant^{-1}), the number of seeds in the capsule (seeds capsule^{-1}), thousand-seed weight (g) and seed yield (kg ha^{-1}) were investigated. 10 m^2 areas were selected and harvested for collecting seed yield data at 80% maturity stage.

Soil analysis

Soil pH was determined by a glass electrode pH meter as described by Jackson (1962) with soil water ratios of 1:2.5. organic carbon was determined by wet-oxidation method by Walkley and Black (1934) as modified by Allison (1965). The organic matter was obtained by multiplying the content of organic carbon by Van Bemmelen, a factor of 1.73 Page et al. (1982). Total N was determined by micro-Kjeldahl digestion by using $CuSO_4$-$NaSO_4$ catalyst mixture was used to determine total N. The ammonia (NH_3) from the digestion was distilled with 40% NaOH into 5% Boric acid and determined by titrating with 0.01 N H_2SO_4 (Jackson, 1973). Available P in the soil sample was measured colorimetrically by the phospho-vanadomolybdate method (Hanson, 1950). Concentration of exchangeable K of the soil samples was determined after the soil by mixing 10 milliliters of 1 normal, pH 7, ammonium acetate with a 1 g scoop of air-dried soil sample and shaking for 5 minutes. The filtered extract is analyzed with an inductively coupled plasma atomic emission spectrometer (ICP-AES) (Chintala et al., 2014). S was determined by turbid metric method with the help of a spectrophotometer.

Statistical analyses

The yield and yield components were statistically analyzed using the Statistix 10. The significance of 'F' value was determined based on analysis of variance (ANOVA) for RCBD design. Mean separation was done by the Least Significant Difference (LSD) test at 5% level of probability.

III. Results and Discussion

Plant height

The plant height of two black cumin varieties varied significantly. The plant height of BARI Kalozira-1 (V_1) varied from 33.16-36.11 cm, whereas in the local variety (V_2), plant height ranged from 20.62-24.73 cm in the year 2017-18 and 2018-19. From the two years of study, it was observed that the plant height of V_1 was higher than V_2, which may be due to the genetic makeup of cultivars and this finding was at par with Azad et al. (2017). Different fertilizer doses affected the plant height non-significantly in 2017-18 but significant in 2018-19. The highest plant height (30.07 and 29.47 cm in 2017-18 and 2018-19, respectively) resulted in T_1, whereas the lowest (27.25 and 25.50 cm in 2017-18 and 2018-19, respectively) in T_4 treatment. There was an increasing trend of plant height was observed with the increase in fertilizer dose (Table 02) in 2018-19.

The plant height varied significantly in interaction effect of variety and fertilization. The plant height values varied in the range of 18.00-38.60 cm and 21.73-35.60 cm in 2017-18 and 2018-19, respectively, as an interaction of variety and fertilization. There was a trend of an increase in the height of plants with the increasing amount of NPK fertilizer dose observed. In the aspect of variety, BARI Kalozira-1 (V_1) is naturally taller in habit compared to the local black cumin (V_2) variety. According to the two years results, the highest plant height, 38.60 and 35.07 cm, was found in the V_1T_3 treatment combination in 2017-18 and 2018-19, respectively whereas the lowest, 18.00 and 21.73 cm in V_2T_4 treatment combination during 2017-18 and 2018-19 (Table 02). In different studies, the plant height of black cumin varied a wide range from 27.9 to 95.1 cm (Ceylan, 1995; Geren et al., 1997; Ozguven and Sekeroglu, 2007). Plant height might be the effect of different genetic and environmental factors. Higher doses of nitrogen fertilizer application accelerate cell division, cell elongation and metabolic processes that result in higher plant growth (Ali et al., 2015a and Ali et al., 2015b).

The number of capsules plant^{-1}

The number of capsule plant^{-1} was significantly varied among the two varieties. The number of capsule plant^{-1} of BARI Kalozira-1 varied from 8.63-9.03 whereas 7.08-7.28 in local variety during 2017-18 and 2018-19 (Table 02). BARI Kalozira-1 provides 20-25 capsules plant^{-1} (Azad et al., 2017). Capsule plant^{-1} significantly varied by the application of different fertilizer doses. The highest number of capsule plant^{-1} was found in T_1 treatment, ranging from 8.77-9.37, whereas the lowest in T_4 treatment ranged from 7.73-8.47 during 2017-18 and 2018-19. Higher number of capsules plant^{-1} results in

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higher number of flowers umbel^{-1}, higher percentage of capsule set and reduced shedding of flowers and capsules that increased yield.

The number of capsules plant^{-1} was significantly affected by the interaction of different fertilizer doses and black cumin variety. The highest number of capsule plant^{-1} was observed in V_1T_1 (9.93-10.53) followed by V_1T_3 (8.67-9.73) and V_1T_2 (8.07-9.07), whereas the lowest in V_2T_4 (6.07-6.20) treatment combination in two years (Table 02). Soil test-based fertilizer dose along with BARI Kalozira-1 (V_1T_1) provided the highest number of capsules plant^{-1} because the NPK dose was provided as per the requirement of the soil. Farmers' dose of fertilizer along with local cultivar provides the lowest number of capsule plant^{-1} because of less nutrient supply and poor yield potentiality. Rana et al. (2012) and Tuncturk et al. (2012) also reported that the number of capsule plant^{-1} was positively influenced by the increased fertilizer dose and high yielding black cumin varieties.

Table 02. Effects of different fertilizer doses and variety on plant height, capsule plant^{-1} on black cumin varieties

Treatments	Plant height (cm)		Capsule plant^{-1} (no.)	
	2017-18	2018-19	2017-18	2018-19
Variety				
V_1	36.11a	33.16a	9.03a	8.63a
V_2	20.62b	24.73b	7.08b	7.28b
LS	***	***	**	***
CV (%)	11.25	10.85	14.66	8.85
SE (±)	1.30	1.28	0.48	0.28
$LSD_{0.05}$	2.79	2.75	1.03	0.61
Fertilization				
T_1	30.07a	29.47a	9.37a	8.77a
T_2	28.37a	30.23a	8.47a	7.73bc
T_3	27.80a	30.60a	7.97a	8.30ab
T_4	27.25a	25.50b	6.43b	7.03c
LS	NS	*	**	**
CV (%)	11.25	10.85	14.66	8.85
SE (±)	1.84	1.82	0.68	0.40
$LSD_{0.05}$	3.95	3.88	1.46	0.87
Variety X Fertilization				
V_1 T_1	33.87a	32.73ab	10.53a	9.93a
V_2 T_1	26.27b	26.20cd	8.20bc	7.60bc
V_1 T_2	34.40a	35.07a	9.07ab	8.07bc
V_2 T_2	22.33bc	24.87cd	7.86bcd	7.40cd
V_1 T_3	38.60a	35.60	9.73ab	8.67b
V_2 T_3	15.90d	26.13cd	6.20cd	7.93bc
V_1 T_4	37.60a	29.27bc	6.80cd	7.87bc
V_2 T_4	18.00cd	21.73d	6.07d	6.20d
LS	**	*	*	**
CV (%)	11.25	10.85	14.66	8.85
SE (±)	2.60	2.56	0.96	0.57
$LSD_{0.05}$	5.59	5.49	2.06	1.23

In column, means followed by different letters are significantly different. In column, means followed by same letters are not significantly different. NS means non-significant, *means significant at 5% level of probability, **means significant at 1% level of probability and ***means significant at 0.1% level of probability.

The number of seeds capsule^{-1}

The number of seeds capsule^{-1} varied significantly between the varieties. BARI Kalozira-1 ranged from 66.02-64.39 seeds capsule^{-1} whereas 54.73-58.88 in local variety during 2017-18 and 2018-19 (Table 03). These findings are at par with Azad et al. (2017). Different fertilizer doses significantly affect the number of seeds capsule^{-1}. The maximum average number of seeds capsule^{-1} (63.10-66.37) was observed in T_1 during the two consecutive years whereas the lowest was in farmers practice (53.93-59.21).

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The number of seeds capsule^{-1} lies between the intervals of 48.40-68.43 according to the result of 2017-18 and 2018-19 interaction of variety and fertilizer dose (Table 03). The highest number of seeds capsule^{-1} was observed in V_1T_1 (67.47-68.43), followed by V_1T_3 (65.83-66.63), V_1T_2 (64.80-66.13) and V_1T_4 (59.47-63.0) whereas the lowest number of seeds capsule^{-1} in V_2T_4 (48.40-55.43) in 2017-18 and 2018-19. These results are at par with the findings of Ghanepasand et al. (2014) and Yousuf et al. (2018). The trend of the values of the number of seeds capsule^{-1} showed that all the fertilizer doses along with BARI Kalozira-1 showed significant differences among them, which means the high yielding variety is more capable of responding to fertilizer doses compared to local black cumin varieties.

Thousand seed weight

The thousand seed weight varied significantly between the varieties. The maximum thousand seed weight was observed in BARI Kalozira-1 (2.79-2.95 g) in 2017-18 and 2018-19. On the other hand, the minimum seed yield was observed in local variety (2.52-2.55 g) in 2017-18 and 2018-19. A significant difference was observed in thousand seed weights as the effect of different fertilizer doses. The maximum thousand seed weight was observed in T_1 treatment (3.04-3.12 g), whereas minimum was in T_4 (2.47-2.53 g) in 2017-18 and 2018-19.

Table 03. Effects of different fertilizer doses and variety on seed capsule^{-1}, 1000 seed weight, seed yield of black cumin varieties

Treatments	Seeds capsule^{-1} (no.)		1000 seed weight (g)		Seed yield (t ha^{-1})	
	2017-18	2018-19	2017-18	2018-19	2017-18	2018-19
Variety						
V_1	66.02a	64.39a	2.95a	2.79a	1.17a	1.01a
V_2	58.88b	54.73b	2.55b	2.52b	0.77b	0.73b
LS	***	***	***	***	***	***
CV (%)	3.42	3.28	6.12	3.61	13.87	10.12
SE (±)	0.87	0.79	0.06	0.03	0.055	0.036
$LSD_{0.05}$	1.86	1.71	0.14	0.08	0.11	0.077
Fertilization						
T_1	66.37a	63.10a	3.12a	3.04a	1.14a	1.03a
T_2	62.10b	59.97b	2.65b	2.52bc	0.94b	0.89b
T_3	62.19b	61.25ab	2.71b	2.61b	1.05ab	0.95ab
T_4	59.21c	53.93c	2.53b	2.47c	0.75c	0.64c
LS	***	***	***	***	**	***
CV (%)	3.42	3.28	6.12	3.61	13.87	10.12
SE (±)	1.23	1.12	0.09	0.05	0.07	0.05
$LSD_{0.05}$	2.64	2.41	0.20	0.11	0.16	0.10
Variety X Fertilization						
V_1 T_1	68.43a	67.47a	3.45a	3.21a	1.33a	1.15a
V_2 T_1	64.30b	58.73b	2.79bc	2.87b	0.96bc	0.90bc
V_1 T_2	66.13ab	64.80a	2.86bc	2.73bc	1.13ab	1.00ab
V_2 T_2	58.13c	56.67bc	2.57cd	2.50de	0.80c	0.74d
V_1 T_3	66.63ab	65.83a	2.91b	2.66cd	1.30a	1.15a
V_2 T_3	57.67c	55.13c	2.40d	2.37e	0.76cd	0.77cd
V_1 T_4	63.0b	59.47b	2.59cd	2.59cd	0.94bc	0.75cd
V_2 T_4	55.43c	48.40d	2.47d	2.34e	0.56d	0.52e
LS	***	***	*	*	**	**
CV (%)	3.42	3.28	6.12	3.61	13.87	10.12
SE (±)	1.74	1.59	0.13	0.07	0.11	0.07
$LSD_{0.05}$	3.73	3.42	0.29	0.16	0.23	0.15

In column, means followed by different letters are significantly different. In column, means followed by same letters are not significantly different. NS means non-significant, *means significant at 5% level of probability, **means significant at 1% level of probability and ***means significant at 0.1% level of probability.

The interaction effect of fertilizer dose and varieties on thousand seed weight showed significant differences among the treatments in both the years 2017-18 and 2018-19. The highest thousand seed

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weight was observed in V_1T_1 (3.21-3.45 g) followed by V_1T_3 (2.66-2.91 g) whereas the lowest was in V_2T_4 (2.34-2.47 g) in two years trial (Table 03). Thousand seed weight is influenced by different factors like variety, growing seasons, fertilizer dose, growing conditions, climatic factors and soil characteristics. The different levels of fertilizer doses have a significant effect on the thousand seed weight of black cumin (Rana et al., 2012).

Seed yield

The seed weight yield varied significantly between the varieties. The maximum seed yield of 1.01-1.17 t ha^{-1} was observed in V_1. On the other hand, the minimum seed yield was observed in local variety (0.73-.77 t ha^{-1}) during the production period of 2017-18 and 2018-19. The yield of BARI Kalozira-1 is 1.00 t ha^{-1} (Azad et al., 2017).

A significant difference was observed in seed yield as the effect of different fertilizer doses. The maximum seed yield was observed in T_1 treatment (1.03-1.14 t ha^{-1}) followed by T_3 (0.95-1.05 t ha^{-1}), whereas minimum was in T_4 (0.64-.75 t ha^{-1}) in 2017-18 and 2018-19. Yousuf et al. (2018) found that BARI Kalozira-1 provided 1.15 t ha^{-1} seed yield when recommended dose of chemical fertilizer was applied.

The different levels of fertilizer doses significantly influenced the seed yield of black cumin genotypes varied from 0.56-1.33 and 0.52-1.15 t ha^{-1} in 2017-18 and 2018-19, respectively (Table 03). The highest seed yield was found in V_1T_1 (1.15-1.33 t ha^{-1}), followed by V_1T_3 (01.00-1.30 t ha^{-1}), whereas the lowest one was in V_2T_4 (0.52-0.56 t ha^{-1}) according to the two years value. These findings conform to the findings of Yousuf et al. (2014) and Yousuf et al. (2018). Soil test-based fertilizer dose provided the highest seed yield, which may be due to the effect of the highest number of capsule plant^{-1}, seeds capsule^{-1}, 1000 seed weight observations are at par with the findings of Ozguven and Sekeroglu (2007) and Tuncturk et al. (2012).

Cost and return analysis

The highest gross return (Tk.204600 ha^{-1}) and gross margin (Tk. 130179 ha^{-1}) along with Benefit Cost Ratio (BCR) 2.74 were obtained from BARI Kalozira-1 with soil test-based fertilizer application because of its highest seed yield and lower dose of fertilizers except for farmers' practice (Table 04). On the other hand, the lowest gross return (Tk. 89100 ha^{-1}) and gross margin (Tk. 24414), along with BCR (1.38), were observed in V_2T_4 treatment combination.

The results showed that the treatment V_1T_1 (BARI Kalozira-1 with STB as per FRG, 2012 had the highest average seed yield, gross return, gross margin and BCR among all the treatments. This indicates that V_1T_1 was the most profitable and efficient treatment for black cumin production. The treatment V_2T_4 (Local black cumin variety with farmers practice) had the lowest average seed yield, gross return, gross margin and BCR among all the treatments. This suggests that V_2T_4 was the least profitable and efficient treatment for black cumin production.

Table 04. Cost and return analysis of black cumin influenced by different fertilizer doses and variety at MLT site, Bhuapur, Tangail during Rabi, 2017-18 and 2018-19

Treatments	Average seed yield (Tk./ha) of 2017-18 and 2018-19	Gross return (Tk. ha^{-1})	Variable cost (Tk. ha^{-1})	Gross margin (Tk. ha^{-1})	BCR
V_1 T_1	1.24	204600	74421	130179	2.74
V_2 T_1	0.93	153450	74421	79029	2.06
V_1 T_2	1.22	201300	75681	125619	2.65
V_2 T_2	0.77	127050	75681	51369	1.68
V_1 T_3	1.15	189750	76911	112839	2.47
V_2 T_3	0.76	125400	76911	48489	1.63
V_1 T_4	0.84	138600	64686	73914	2.14
V_2 T_4	0.54	89100	64686	24414	1.38

The selling price of seed = Tk. 165.00 kg^{-1}, price of inputs (Tk kg^{-1}): Urea-16, TSP-22, MoP-15, Gypsum-13, Boric acid-400, cowdung-2, labour wage: Tk. 400 day^{-1}, land leasing cost: Tk. 25000 ha^{-1} during the cropping period, BCR= Benefit Cost Ratio.

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The results also showed that variety V_1 had higher average seed yield, gross return, gross margin and BCR than variety V_2 in all the fertilizer doses. This implies that the variety V_1 was more productive and profitable than the variety V_2 regardless of the fertilizer dose. The fertilization T_1 had higher average seed yield, gross return, gross margin and BCR than the fertilization T_4 in both varieties. This means that the fertilization T_1 was more suitable and profitable than the fertilization T_4 for both varieties. The results suggest that the variety V_1 with the fertilization T_1 can be recommended for black cumin cultivation to obtain higher yield and income. However, further research is needed to assess the sustainability and environmental impact of using different fertilizer doses for black cumin production.

IV. Conclusion

Applying soil test-based fertilizer (106-32-30-12-2-1 kg NPKSZnB ha^{-1}) in BARI Kalozira-1 gave the highest yield and economic return. From the two-year study, it may be concluded that soil test-based fertilizer management package with BARI Kaligira-1 may be recommended for black cumin cultivation for the Charland of Bhuapur, Tangail, under AEZ 8 for higher yield and economic return.

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