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Inorganic fertilization effect on growth and yield attributes of black cumin (*Nigella sativa* L.) as intercrop under cassia (*Cinnamomum tamala*)

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Abstract

Black cumin (*Nigella sativa* L.) is an annual flowering plant. It is predominantly grown for its seeds and oil in open condition, but with its short life cycle and low input requirements it has potential for growing as a profitable intercrop. Cassia (*Cinnamomum tamala*) being perennial and wide spaced crop, it makes possible for cultivation of short duration and closely spaced intercrops during its harvesting period. However, information on nutrient fertilization of black cumin as intercrop remains elusive. The present investigation was conducted at the HRS, Mondouri, BCKV, West Bengal, India with 9 different combinations of inorganic fertilizer in CRBD with 3 replications to find out the optimum combination of nutrients on growth and yield of black cumin as an intercrop with Cassia. Among the various treatments, maximum plant height (68.11 cm), number of primary (6.07) and secondary branches (9) per plant, number of capsule per plant (23.33), 1000 seed weight (2.24g), seed yield hectare^{-1} (3.48 q) and B:C ratio (2.20) were recorded with treatment T_5 (70:40:20 kg NPK ha^{-1}) followed by treatment T_9 (70:40:30 kg NPK ha^{-1}). Treatment combinations with higher levels of nutrients had significant effects on growth components and seed yield. From the results of this experiment, treatment T_5 (70:40:20 kg NPK ha^{-1}) can be recommended as the optimum fertilization dose for obtaining maximum growth, seed yield and profitable economic return of black cumin as an intercrop during harvesting period of cassia leaves under alluvial plains of West Bengal.

Key words: Black cumin, cassia, *Cinnamomum tamala*, inorganic fertilizer, intercrop and nutrient management

Introduction

Black cumin (*Nigella sativa* L.) is an annual spicy herb and belongs to the *Ranunculaceae* family. Black cumin is a short duration crop and cultivated for seed yield, oil production and medicinal uses. It originated in the Mediterranean region and widely cultivated throughout the South Europe, North Africa, countries of Middle East, Turkey, Iran, China, Japan and Indian Sub-Continent (Rana *et al.,* 2012; Bhutia *et al*., 2015).

In India, black cumin is commercially cultivated in Punjab, Himachal Pradesh, Madhya Pradesh, Jharkhand, Assam, West Bengal and Andhra Pradesh (Vijay and Malhotra, 2002). Extracts of the black cumin seeds have many therapeutic effects such as anti-diabetes, antibacterial, and antitumor (Kanter *et al.,* 2003; Hussein *et al.,* 2005), anti-inflammatory effect and anti-cancer properties (Woo *et al*., 2012).

Intercropping is one of the most important techniques which illustrate growing of crops under different plant geometry (Mehta *et al.,* 2017). With increasing population, the per capita availability of land and accessible natural resources are declining to meet the demand for food, shelter and fuel production. This increases the opportunity for vertical expansion of agriculture, which can be possible by increasing the productivity of resources per unit area per unit time as the possibility of horizontal expansion of agriculture system is very limited. The intercropping system is a very important avenue in this direction, which aimed at increasing productivity per unit area per unit time and insurance against total crop failure under aberrant weather conditions (Mullick *et al*., 1993). Plant nutrition is one of the key factors influencing the productivity of crop plants. Nutrient management in intercropping is an important area where it is necessary to supply nutrient for both the crops along with realizing higher nutrient use efficiency.

Cassia is grown at a recommended spacing of 3 x 2.5m and this makes it desirable and suitable to utilize the inter space for growing other crops especially seed spices at the juvenile stage and during harvesting period. The harvesting period of cassia leaves starts from October to November which extends up to March which is the ideal time for cultivation of seed spices such as black cumin. Although, there are many researches related to nutrient management of black cumin in open condition, there is little information available pertaining to intercrop including optimum fertilization dose of N, P and K.

Gendy *et al*. (2018) recorded that intercropping of black cumin and fenugreek has increased most of the parameters of both the components compared to sole production with a limited use of external inputs. This provides us a notion to carry out studies of black cumin as intercrop with other crops to increase per capita yield and return. Thus, the present experiment was therefore, undertaken to find out the optimum fertilization dose of inorganic nutrients on growth and yield of black cumin as an intercrop with cassia (*Cinnamomum tamala*) during its harvesting period to obtain extra return to the growers.

Material and methods

Experimental site: The field experiment was undertaken during rabi season of 2016-17 for studying the effect of inorganic fertilization on growth and yield attributes of Black cumin as intercrop under cassia at Horticultural research station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal. The geographic coordinates of the experimental location is 23.5° North Latitude and 9.75° East Longitude with an elevation of 9.75 m above mean sea level.

Experimental design and material: The design of the experiment was randomized block design (RBD) and a local variety was used. The experiment comprising of 9 treatments *viz.*, T_1 (Control), T_2 (40:40:20 kg NPK ha^{-1}), T_3 (50:40:20 kg NPK ha^{-1}), T_4 (60:40:20 kg NPK ha^{-1}), T_5 (70:40:20 kg NPK ha^{-1}), T_6 (40:40:30 kg NPK ha^{-1}), T_7 (50:40:30 kg NPK ha^{-1}), T_8 (60:40:30 kg NPK ha^{-1}) and T_9 (70:40:30 kg NPK ha^{-1}) was replicated thrice.

Field preparation: Raised beds of 2 x 1.5 m were laid out between the cassia rows of 3 x 2.5 m. Farm yard manure (FYM) @ 20 t ha^{-1} was applied at the time of field preparation as basal dose. 1/3rd of N and full dose of P and K were applied as basal and remaining 2/3rd of N was applied in two equal splits at 30 and 60 days after sowing (DAS). The sources of N, P_2O_5 and K_2O were Urea, single super phosphate and muriate of potash respectively. The seeds of black cumin were soaked in water for 24 hours before sowing to facilitate early germination and treated with Carbendazim @ 2g kg^{-1} seeds to minimize seed borne diseases. Seeds were sown in line of 30 cm during middle of November. The seedlings were thinned out at 15 cm apart 30 days after sowing along with first weeding and keeping 10 plants per row.

Data collection: The observations on growth and yield were recorded from five randomly selected plants. Growth parameters such as plant height and dry matter accumulation were recorded starting at 30 days after sowing and subsequently at 15 days interval till 100 days of crop growth. The primary and secondary branches were recorded at 100 days after sowing. Average number of capsules per plant and capsule size were recorded at harvesting stage. The crop was harvested during first week of April.

Statistical analysis: The data from different treatments were statistically analyzed by employing completely RBD at 5% level of significance. The data were analyzed with the help of a window-based computer package OPSTAT (Sheoran, 2004).

Results and discussion

The results (Table 1) showed that the duration of first flower bud initiation (44.33 DAS), 50% flowering (55.33 DAS), pod initiation (79.67 DAS) and pod maturity (109.33 DAS) were recorded earliest in case of T_1 (control) whereas the maximum time requirement for flower bud initiation (50 DAS), 50% flowering (63.33 DAS), pod initiation (85.33 DAS) and pod maturity (115 DAS) was recorded in T_9 (70:40:30 kg NPK ha^{-1}). The variation in the number of days may be attributed due to different levels of fertilizer. With increase in level of nitrogen, 50% flowering as well as crop maturity was delayed gradually in T_9 (70:40:30 kg NPK ha^{-1}) due to prolonged vegetative growth of the plant. Similar trend was observed by Ozguven and Sekeroglu (2007) and Jagdale and Dalve (2010) respectively, who also reported that days required for 50% flowering and maturity of seed crop were found to be delayed with an increased level of nitrogen ha^{-1} (120 kg).

Table 1. Effect of fertilizer doses on duration to attain different phenophases of black cumin

Treatments	Duration (Days from sowing)					
	Germination	50% bermination	First flower bud initiation	50% flowering	First pod initiation	Pod maturity
T_1	9.00	21.00	44.33	55.33	79.67	109.33
T_2	8.66	19.33	46.33	57.00	81.67	110.00
T_3	9.33	18.00	48.00	58.00	82.33	112.00
T_4	9.00	19.33	48.67	60.33	83.33	112.33
T_5	9.00	18.33	49.67	63.00	84.33	113.67
T_6	8.33	18.33	46.67	56.67	81.33	110.33
T_7	9.33	19.00	47.67	58.33	82.67	112.33
T_8	9.00	19.33	49.33	61.33	83.00	113.33
T_9	8.66	19.33	50.00	63.33	85.33	115.00
LSD (0.05)	--	1.620	2.696	1.328	1.603	1.549

Plant height: Fertilizer treatments have significant influence on plant height. The maximum plant height was recorded in T_5 (70:40:20 kg NPK ha^{-1}) at 100 days after sowing (68.11 cm) followed by T_9 (70:40:30 kg NPK ha^{-1}) (64.93 cm). Minimum plant height was recorded in T_1 (control) (53.93 cm). T_5 treatment combination showed significant variation in plant height as compared to other combinations during the growth period (Table 2). Percentage increase in plant height was recorded less with increase in age of the plants. Valadabadi and Aliabadi (2011) found that plant height of black cumin ranging from 58 to 82 cm. Sultana *et al*. (2019) also reported similar findings with application of 60:45 kg NP ha^{-1}.

Dry matter: Total dry matter weight per plant was increased gradually with the higher level of applied fertilizer dose (Table 3). Dry matter accumulation which includes root, stem, leaf and fruit was significantly greater (6.19 g plant^{-1}) in case of T_9 (70:40:30 kg NPK ha^{-1}) and T_5 (70:40:20 kg NPK ha^{-1}) (6.01 g plant^{-1}) at 100 DAS. Nitrogen increases the photosynthetic pigments which in turn increased the amount of metabolites synthesized and consequently resulted in higher dry matter accumulation. Similar result was also reported by Ali *et al*. (2015) with higher level of fertilizer.

Number of primary and secondary branches: Yield of black cumin plant varies with the variation in number of primary and secondary branches. The data revealed that number of primary branches (6.07) and secondary branches (9.00) per plant was maximum in T_5 (70:40:20 kg NPK ha^{-1}) as compared to T_1 (control) which recorded minimum, 4.67 and 5.27, respectively (Table 4). Nataraja *et al.* (2003) found that plants grown at 40 kg phosphorus ha^{-1} recorded maximum number of branches (13.56) in open condition. Özgüven and Şekeroğlu (2007) also reported that the highest number of branches was obtained from higher nitrogen doses (90 kg N ha^{-1}).

Number of capsules per plant: Capsules per plant are important component that directly contribute to the total yield of black cumin. Number of capsules

Table 2. Effect of fertilizer doses on plant height (cm) of black cumin from 30 to 100 DAS

Treatments	30 DAS	44 DAS	58 DAS	72 DAS	86 DAS	100 DAS
T_1	6.38	8.92	25.40	47.40	52.64	53.93
T_2	6.91	9.98	28.73	52.70	57.13	59.21
T_3	7.00	12.09	30.97	55.17	60.41	61.67
T_4	7.10	12.30	32.00	56.87	62.25	64.86
T_5	7.59	13.08	33.47	59.70	65.36	68.11
T_6	6.63	11.54	28.17	51.97	55.55	57.89
T_7	6.94	11.91	30.37	54.13	58.23	60.15
T_8	7.09	12.08	31.40	55.83	60.64	64.53
T_9	7.27	12.38	33.40	57.17	62.50	64.93
CD at 5%	0.25	1.01	0.56	1.36	0.82	0.59

Table 3. Effect of fertilizer doses on dry matter accumulation (g per plant) of black cumin

Treatments	30 DAS	44 DAS	58 DAS	72 DAS	86 DAS	100 DAS
T_1	0.05	0.12	0.58	1.20	2.15	4.25
T_2	0.06	0.13	0.69	1.41	3.21	4.86
T_3	0.08	0.14	0.83	1.65	3.50	5.40
T_4	0.08	0.17	0.91	2.08	3.63	5.68
T_5	0.11	0.18	0.97	2.37	4.20	6.01
T_6	0.07	0.14	0.77	1.53	3.41	4.94
T_7	0.07	0.15	0.85	1.92	3.50	5.02
T_8	0.10	0.18	0.94	2.18	4.10	5.76
T_9	0.12	0.18	1.07	2.53	4.29	6.19
CD at 5%	0.0071	0.0097	0.009	0.0194	0.1066	0.0369

per plant (Table 4) was significantly affected by the increased dose of fertilizer treatment which is also related to the plant height. Highest number of capsules (23.33) per plant was found in T_5 (70:40:20 kg NPK ha^{-1}) followed by T_9 (70:40:30 kg NPK ha^{-1}) (19.60). Here, T_5 shows significant variation as compared to other treatments and control due to higher level of nitrogen. In a different study, Rana *et al.* (2012) found that the highest number of capsules (32.25) was recorded at 60:120 kg NP ha^{-1} in open conditions. The present result is far from this mentioned reference as this could be the optimum environment of chemical and physical properties of the soil and the cropping system as in present investigation it was raised as intercrop where even the light penetration is reduced due to the canopy of cassia crop.

Capsule size: It is represented by the length and diameter of the capsule. Capsule size was significantly influenced by the increased levels of fertilizer (Table 4). The mean maximum length (1.38 cm) and (1.36 cm) was recorded in T_9 (70:40:30 kg NPK ha^{-1}) and T_5 (70:40:20 kg NPK ha^{-1}), respectively. The diameter of the capsule was recorded at par in all the treatments. Ali *et al.* (2015) reported capsule length of the black cumin was significantly influenced by the levels of fertilizer. Among the treatment combinations, higher level of fertilizer gave the maximum capsule length (1.17 cm) and capsule breadth (0.82cm) at harvest.

Seeds per capsule: Capsule size directly affects the number of seeds per capsule and contributes to the total yield of black cumin. There was a significant difference in number of seeds per capsule between the higher level of fertilizer dose treatment and control plots. The highest number of seeds per capsule (103.66) was recorded in T_9 (70:40:30 kg NPK ha^{-1}) treatment combination and the lowest (76.22) was observed in T_1 (control). The results are in agreement with the research findings of Ghanepasanda *et al.* (2014).

Test weight: 1000-seed weight is an important yield attributing character. The weight of 1000-seed was significantly affected by the fertilizer treatments (Table 4). The maximum 1000-seed weight (2.24 g) and (2.17) was recorded in treatment T_5 and T_9 respectively, and the minimum 1000-seed weight (1.92 g) was noted in treatment T_1 (control). Kaheni *et al.* (2013) also found significant effect of fertilizer levels on thousand seed weight of black cumin. Similar results were also reported by Ali *et al.* (2015) and Yousuf *et al.* (2018).

Yield: Generally high yield is associated with maximum number of capsules per plant and seeds per pod. The data recorded for seed yield of black cumin under different treatments (Table 4) indicate significant differences amongst them. T_5 (70:40:20 kg NPK ha^{-1}) exhibited its statistical superiority over rest of the treatments with maximum yield (3.48 q ha^{-1}) followed by T_9 (70:40:30 kg NPK ha^{-1}) (2.96 q ha^{-1}) which was at par with T_3 (50:40:20 kg NPK ha^{-1}) (2.81 q ha^{-1}). The minimum seed yield (1.46 q ha^{-1}) was

Table 4. Effect of fertilizer doses on yield and yield components of black cumin

Treatments	Branches		No. of capsule per plant	No. of seeds per capsule	Capsule size (cm)		1000 seed wt. (g)	Yield (q ha^{-1})	B:C ratio
	Primary	Secondary			Length	Breadth			
T_1	4.67	5.27	9.13	76.22	1.25	0.91	1.92	1.46	0.65
T_2	5.20	5.40	13.60	84.77	1.26	0.92	2.02	1.49	0.40
T_3	5.27	7.87	14.80	89.88	1.32	0.94	2.03	2.02	0.87
T_4	5.73	7.93	19.07	92.22	1.35	0.94	2.11	2.81	1.60
T_5	6.07	9.00	23.33	98.55	1.36	0.95	2.24	3.48	2.20
T_6	4.80	7.47	11.13	86.11	1.27	0.91	2.06	1.95	0.80
T_7	5.27	7.80	16.93	95.44	1.32	0.94	2.08	2.52	1.31
T_8	5.53	8.60	17.80	97.33	1.36	0.95	2.1	2.31	1.10
T_9	5.87	8.87	19.60	103.66	1.38	0.96	2.17	2.96	1.68
CD at 5%	0.2396	0.1485	1.1353	1.2295	0.0543	0.0242	0.0983	1.3514	

Note: T_1 (Control), T_2 (40:40:20 kg NPK ha^{-1}), T_3 (50:40:20 kg NPK ha^{-1}), T_4 (60:40:20 kg NPK ha^{-1}), T_5 (70:40:20 kg NPK ha^{-1}), T_6 (40:40:30 kg NPK ha^{-1}), T_7 (50:40:30 kg NPK ha^{-1}), T_8 (60:40:30 kg NPK ha^{-1}) and T_9 (70:40:30 kg NPK ha^{-1})

recorded under T_1 (control). The increment in seed yield under interaction of fertilizer might be associated with synthesis of more chlorophyll for photosynthesis resulting in promotion of plant development (Ashraf *et al.,* 2005). A positive correlation was observed between nutrient level and seed yield indicating the enhanced fertilizer use by the crop. The results of nutrient interactions are in conformity with Sultana *et al*. (2019) in black cumin with higher dose of N and P.

Economics of cultivation: Gross returns, net returns and benefit cost ratio was worked out for the entire fertilizer management practices taking into consideration of the inputs used for crop production during the year of study. Maximum net return of Rs. 54,990 ha^{-1} was recorded with the application of T_5 (70:40:20 kg NPK ha^{-1}). The profitability increased with increasing N and lower K applications. The highest Benefit Cost Ratio (B: C ratio) of 2.20: 1 was recorded with T_5 (Table 4).

In conclusion, nutrient fertilization played a significant role on the growth and seed yield of black cumin. The fertilizer treatment T_5 (70:40:20 kg NPK ha^{-1}) and T_9 (70:40:30 kg NPK ha^{-1}) resulted in higher growth and yield attributes of black cumin as intercrop. But considering the profitability of the cultivation, maximum net return of Rs. 54,990 ha^{-1} was recorded with the application of T_5. Hence, the application of T_5 (70:40:20 kg NPK ha^{-1}) can be recommended as the optimum dose for obtaining maximum growth, seed yield of black cumin as an intercrop to obtain additional benefit during harvesting period of cassia leaves under alluvial plains of West Bengal.

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