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IMPACT OF NUTRIENT MANAGEMENT ON YIELD RELATED TRAITS OF BLACK CUMIN IN NEW ALLUVIAL ZONES OF WEST BENGAL INDIA

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ABSTRACT

During the 2019–23 *rabi* season, experiment was carried out at Horticultural Research Station, Mandouri farm, using randomized block design with three replications using various treatment combinations. The highest plant height of 23.70 cm at first flowering, 40.68 cm at 50% blooming, and 79.10 cm at harvest was recorded by T_6 (80:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}). T_6 has more major and secondary branches (7.19 and 23.93, respectively). At all growth stages, T_6 had the highest reported number of capsules (24.59), capsule size (1.33cm), fresh capsule weight (2.25g), dry capsule weight (1.49g), number of seeds per capsule (105.28), number of seeds per plant (2007.51), 1000 seed weight (2.07g), straw yield (12.29g), fresh plant weight (32.98g), dry plant weight (18.42g), seed weight per plant (4.31g), seed yield per plot (0.86kg), projected seed yield (8.61 q ha^{-1}), and projected oil yield (4.48Lha^{-1}) in comparison to farmers' practices. There was a considerable impact of raising NPK along with organic fertilizer levels on plant height, branch count; seed production increased its yield.
***Keywords* :** Branches, fertilizer, seed weight and yield.

Introduction

The use of herbal supplements and medicinal goods has increased so much over the past four decades that around eighty percent of the world's population now depends on them for some aspect of primary healthcare Ekor (2014). The Ranunculaceae family includes the only annual medicinal and spice plant *Nigella sativa* L. native to southern Europe, North Africa, and South and West Asia Tuncturk *et al.* (2012), it is extensively grown for its oil and seed yield in Syria, Egypt, Saudi Arabia, Iran, Pakistan, India, and Turkey Riaz *et al.* (1996). Many illnesses that contemporary medical systems either cannot treat or only infrequently can are treated using medicinal plants Abadi *et al.* (2015). According to Ustun *et al.* (1990) and Ashraf *et al.* (2006), the seeds of this plant contain 30–35% oil and 0.5–1.5% essential oil, which have many applications in the food and medicinal industries. Thymoquinone, a member of the terpenoids chemical class and one of the most significant components of essential oils, involves the plant being studied for its potential to affect major human diseases like cancer Banerjee *et al.* (2010) or the metabolic syndrome Razavi and Hosseinzadeh (2014). Yield and quality are critical factors in the successful use of *N. sativa* for various medicinal reasons Datta *et al.* (2012). According to Mohammed *et al.* (2014), the growth and quality of medicinal plants are enhanced by the proper use of fertilizers. One of the primary elements in achieving high crop production yield and quality is agricultural methods. A reduced yield and quality of plants can be the result of improper or delayed cultural techniques. In order to determine how varying levels of phosphate Kizil *et al.* (2008) and nitrogen Ashraf *et al.* (2006); Tuncturk *et al.* (2012) fertilizers affect various agronomic traits, yield, and yield components in nigella, numerous experiments have been carried out. There is still a dearth of information on plant development and yield under fertilization because nigella has only been the subject of scientific research in the last forty years. Farmers have been observing indiscriminate fertilizer usage in West Bengal's new alluvial zones, which raises production costs and degrades soil fertility. In order to standardize the fertilizer schedule for the nigella crop in new alluvial areas of West Bengal, the study's objectives were to ascertain the effects of both organic and inorganic NPK fertilizers on the crop's growth, yield, and quality indices.

Materials and Methods

At the Horticultural Research Station, Mandouri farm, Bidhan Chandra Krishi Viswavidyalaya, Nadia, West Bengal, field tests were conducted from 2019 to 2023. The study's objective was to determine how seed production and volatile oil were affected by both organic and inorganic NPK fertilizers. The study employed a fully randomized block design with three replicates. The main plots' plant densities and the subplots' fertilizer treatments were assigned at random. Each of the experimental units measured 1 ×1.5 meters. During the first two weeks of November, seeds were planted for each of the four growth seasons. Clay loam (pH-7.6) was the texture of the soil. The mature stage of the plants was collected in the first two weeks of April. At the moment of fruit ripening, data were recorded. The Soxhlet device was used to measure the volatile oil in crushed and dried seeds. Fertilizers were applied in two separate doses (as indicated in table 1): a base dosage prior to planting and the remainder fertilizer applied 45 days following plant emergence but before blooming. Measurements of plant height in centimeters at the stage of physiological maturity from ground level to the tip of the plant were among the growth and yield characteristics for which data were recorded. Five tagged plants from the four middle rows were counted to determine the number of primary branches per plant. The number of capsules per plant and the number of seeds per capsule were then counted on a plant-by-plant and capsule-by-capsule basis, respectively. Each of the five tagged plants' seeds was counted, weighed using an analytical balance, and expressed in grams to get the thousand seed weight. Following three days of drying and harvesting, the total weight of the plants from the center sub-plot areas was measured to determine the straw yield. Seed yield was determined by measuring the seed weight of plants used for calculating projected seed yield. Using the SAS program (SAS, 1989) and the method proposed by Panse and Sukhatme (1985), the data gathered from agricultural attributes were statistically analyzed of variance at a significance level of 5% and the average values was used to compare the Duncan Multiple Range Test.

Table 1: Treatment combinations

T_1	40: 40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}
T_2	40:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}
T_3	60:40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}
T_4	60:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}
T_5	80:40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}
T_6	80:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}
T_7	70:50:0 NPK kg ha^{-1} (farmer's practice)

Results and Discussions

According to the data in Tables 2 and 3, fertilizer levels had a major impact on growth parameters. T_6 (80:40:20 NPK kg ha-1 + FYM 20 t ha-1) had the tallest plants, measuring 23.70 cm at first flowering, 40.68 cm at 50% flowering, and 79.10 cm at harvest. T_4 (60:40:20 NPK kg ha-1 + FYM 20 t ha-1) came in second with 23.55 cm, 35.65 cm, and 73.56 cm, respectively. As nitrogen plays a significant and essential role in the synthesis of amino acids, the building blocks of proteins and protoplasm, its availability is crucial for the growth of plants Troug (1973). Vigorous vegetative growth is linked to a sufficient supply of nitrogen, and more effective utilization of the nutrients that are available ultimately results in increased output. One possible explanation is the high amount of nitrogen applied, which in turn promotes plant growth and processes like cell division, cell enlargement, and metabolic processes George (2000). Another possibility is the application of phosphorus, which is crucial for plant bioenergetics as a component of ATP during photosynthesis Singh *et al.* (1999). Phosphorus is crucial for plant growth and flowering, followed by seed formation, because ATP may be used to change the activity of different enzymes through phosphorylation and for the creation of numerous plant bimolecular components Hammo (2008). Number of primary and secondary branches were more in T_6 with 7.19 and 23.93 respectively followed by T_5 (7.14) for primary branches, T_4 (22.10) for secondary branches.

While the number of tertiary branches per plant was unaffected by the high nitrogen treatment, Ali *et al.* (2015) noted that the number of primary and secondary branches per plant was greatly enhanced, possibly due to the stimulation of lateral shoot development.

These findings are consistent with those of Ahmed (1997) and could be related to nitrogen, which promotes plant growth and development and subsequently increases stem diameter Al-Naimi (1987) and Uchida (2000). The development of the plant's roots is influenced by the phosphorus in the soil. Depending on phosphorus treatments, the root's contact area grows as the root grows, leading to a boom in productivity and making it easier for the plant to absorb the other nutrients in greater amounts Marschner (1995). At every development stage, the highest fresh plant weight (32.98g), dry plant weight (18.42g), and straw yield (12.29) were observed under T_6, followed by T_4 (28.99g, 14.45g and 11.66g, respectively), and T_7 (lowest). The plant system and root zone may have superior nutritional conditions when nitrogen fertilizer levels are higher. It is well known that nitrogen plays a crucial role in the biological processes of protein as structural elements and biological catalysts, phosphorylated compounds in energy transformations, nucleic acids in the transfer of genetic information and the control of cellular metabolism, and chlorophyll in the harvesting of solar energy. The cause might be related to sufficient nitrogen, which influences both yield and quality by encouraging aerial vegetative growth, raising the top/root ratio, and being necessary for the creation of fruit and seeds Okeno (2001). Phosphorus, which helps with root development, flower initiation, and increases dry matter accumulation in seeds and fruit development Ibrikci *et al*. (2005), and nitrogen, which improves the quality and amount of dry matter Tucker (1999).

According to Phetpradap *et al.* (1994), the sole modification to the number of capsules per plant was the fertilization treatment. Capsule size (1.33cm), fresh weight (2.25g), dry weight (1.49g), and number of capsules (24.59) were highest in T_6, followed by T_4 (22.71, 1.28cm, and dry weight 1.32g), in that order. More capsules were formed in the current investigation as the dosages of potassium and phosphorus were increased. According to Tucker (1999) and Uchida (2000), the number of branches has a direct impact on the number of capsules. Additional nutrient applications in black cumin increase the number of branches and capsules per plant, allowing plants to produce more fruitful branches under ideal growing conditions Ozguven and Sekeroglu (2007). Other studies also found that the nigella crop responded favorably to inorganic fertilization Rana *et al.* (2012); Khalid and Shedeed (2015); Yimam *et al*. (2015). Nevertheless, T_6 had the most seeds per capsule (105.28), following fertilizer application. The results showed that there were less seeds in the capsule than Toncer and Kizil (2004) had shown. Furthermore, Hadi *et al.* (2015) discovered that the number of seeds per capsule was unaffected by the FYM application in the nigella crop. Many factors, including variety, growing conditions, climate, and soil characteristics, affect the weight of a thousand seeds; however, neither organic nor inorganic NPK fertilizers have an impact. It is highest in T_6 (2.07g), while the other treatments produced levels that were comparable to the control but not statistically greater. According to Yimam *et al*. (2015) and Ali *et al*. (2015), the thousand-seed weight was unaffected by the rise in inorganic fertilizer levels. This conclusion is consistent with their findings. Higher thousand seed weight may also be a result of available phosphorus in the soil for crops Manske *et al*. (2001). Talafih *et al*. (2007) provided support for the quantity of seeds per plant (2007.1) seen in T_6, but the findings showed that this feature is unaffected by treatment combinations. In terms of fertilizer treatments, the results indicated that NPK fertilization treatments significantly increased plant seed output as compared to farmers' practices in all seasons. The T_6 plot had the highest seed yield per plot (0.86 kg), followed by the T_4 plot (0.69 kg), and the predicted seed yield (6.98 q ha^{-1}) was higher than that of the control plots. Seed yield in the crop is directly impacted by yield components including the quantity of branches and capsules Geren *et al*. (1997). The findings of Hammo and Al-Atractii (2006) are consistent with this outcome. According to Seyyedi *et al*. (2015), increasing potassium levels may greatly boost seed output. NPK nutrient supplementation may have improved seed output because it significantly accelerated development through the application of these nutrients, which improved the plant's ability to efficiently partition photosynthates to the sink Rai *et al*. (2002) and Bommi *et al*. (2010). Temperature variations and varying rainfall regimes in various regions may account for these variations in average seed yields Roussis *et al*. (2017).

According to Tuncturk *et al.* (2012), yield was impacted by the combined supply of NPK, which is consistent with this conclusion. A higher yield could be the consequence of more vigorous plant development brought on by an increase in these nutrients, as evidenced by increased plant height, branches, leaves, and capsules, which would increase the total biomass of the plant Rana *et al*. (2012); Ali *et al*. (2015). It is widely acknowledged that proper application of chemical fertilizer enhances plant quality and output. The positive impacts of organic fertilization on crop yields were amply demonstrated by data from other researchers Efthimiadou *et al.* (2009); Bilalis *et al*. (2012).

According to Nakhaei *et al.* (2012), the greatest results for volatile oil and seed yield came from high mineral NPK fertilization. According to a review of the data in Table 3, the volatile oil production in nigella seeds was one of the qualitative features for which a higher quantity of fertilizer was statistically significantly better than other treatments. The highest volatile oil content value (4.48 Lha^{-1}) was observed in T_6, followed by T_4 (3.63 L ha^{-1}) and T_1 (1.83 L ha^{-1}). In the nigella crop, Ashraf *et al.* (2006) and Sultan *et al.* (2009) also reported similar results. The genetic potential of populations and many environmental variables may account for these discrepancies between our findings and those of other studies Sushama and Jose (1994).

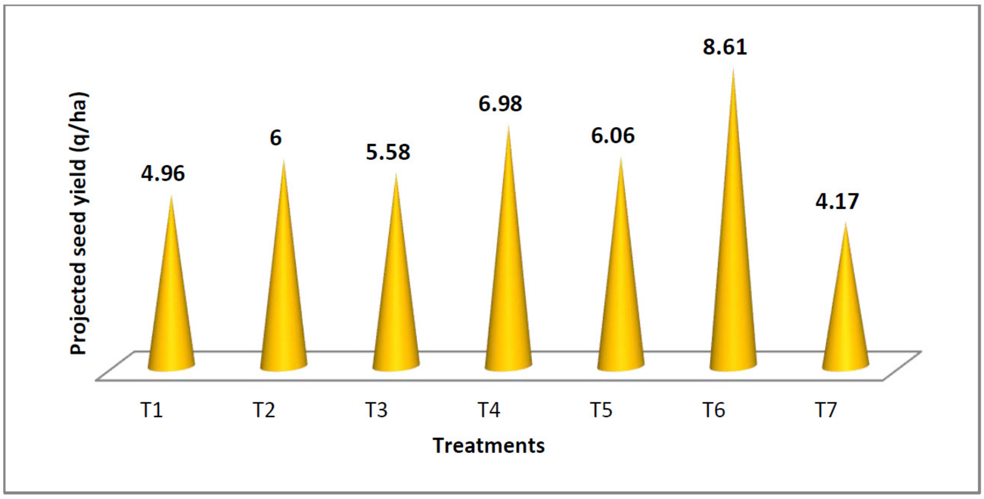

Fig. 1: Effect of nutrient management on projected seed yield

The benefit-cost ratio of the various treatment combinations shown in Table 4 makes it evident that T_6 produced the highest net profit of Rs. 84498.79 ha^{-1} with a B: C ratio of 1:1.96, followed by T_4 treatment combination, which produced a net profit of Rs. 52110.38 with a B: C ratio of 1:1.60 by Swetal *et al.* (2012). Therefore, it can be said that NP fertilizer and additional potash fertilizer have demonstrated an impact on higher yield and quality as well as the highest returns per hectare.

Table 4: Economic analysis on impact of nutrient management in black cumin

Treatments	Yield (qha^{-1})	Expenditure (Rs. ha^{-1})	Gross Returns (Rs. ha^{-1})	Net Returns (Rs. ha^{-1})	BC ratio
T_1	4.97	86628.03	99333.33	12705.3	1.15
T_2	6.01	87211.36	120133.30	32921.97	1.38
T_3	5.58	86906.29	111600.00	24693.71	1.28
T_4	6.98	87489.62	139600.00	52110.38	1.60
T_5	6.06	87184.55	121200.00	34015.45	1.39
T_6	8.61	87767.88	172266.70	84498.79	1.96
T_7	4.89	87508.28	101000.00	13491.72	1.15

Conclusions

In conclusion, two important yield components in black cumin the number of capsules per plant, seed yield, and oil production were all positively impacted by plants that received increasing dosages of inorganic NPK. The fertilizer combination T_6 (80:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}) produced the highest seed yield, per the study's results. There was a considerable impact of raising fertilizer levels on plant height, branch count, and seed production. Fertilization with nitrogen, phosphate, and potassium has a significant impact on black cumin yield and this T_6 concentration can be recommended for farmers in this area against their fertilizer practices for reducing their inputs cost and increase their output. More agricultural and technological research should be done to produce high-quality and high-yield black cumin.

Table 2: Effect of nutrient management on growth related traits in black cumin

Treatment	Plant height at first flowering (cm)	Plant height at 50% flowering (cm)	Plant height at harvest (cm)	Number of primary branches	Number of secondary branches	Number of capsules per plant	Capsule size (cm)	Fresh capsule weight (g)	Dry capsule weight (g)
T_1	22.92^{a}	34.61^{b}	68.70^{b}	6.92^{ab}	18.33^{cd}	20.50^{bc}	1.16^{cd}	2.29^{a}	1.22^{bc}
T_2	22.78^{a}	32.31^{b}	71.96^{b}	6.40^{ab}	19.60^{bc}	18.01^{c}	1.24^{bc}	1.90^{a}	1.20^{bc}
T_3	21.65^{ab}	33.51^{b}	71.13^{b}	6.94^{ab}	19.08^{bcd}	19.35^{bc}	1.20^{bcd}	2.07^{a}	1.15^{bc}
T_4	23.55^{a}	35.65^{b}	73.56^{b}	6.13^{b}	22.10^{ab}	22.71^{ab}	1.28^{ab}	2.10^{a}	1.32^{b}
T_5	21.56^{ab}	32.65^{b}	71.45^{b}	7.14^{a}	17.66^{cd}	17.63^{c}	1.16^{cd}	2.08^{a}	1.22^{bc}
T_6	23.70^{a}	40.68^{a}	79.10^{a}	7.19^{a}	23.93^{a}	24.59^{a}	1.33^{a}	2.25^{a}	1.49^{a}
T_7	18.71^{b}	31.56^{b}	69.76^{b}	6.18^{b}	16.03^{d}	17.23^{c}	1.12^{d}	1.39^{b}	1.06^{c}
S. Em (±)	0.88	1.39	1.46	0.25	0.99	1.26	0.02	0.12	0.05
C.D (P=0.05)	2.76	4.35	4.57	0.78	3.10	3.93	0.07	0.37	0.18

[T_1- 40: 40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_2- 40:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_3- 60:40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_4- 60:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_5- 80:40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_6 -80:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_7-70:50:0(NPK)]

Table 3: Effect of nutrient management on growth related traits in black cumin

Treatment	Number of seeds per capsule	Number of seeds per plant	1000 seed weight (g)	Straw yield (g)	Fresh plant weight (g)	Dry plant weight (g)	Seed weight per plant (g)	Seed yield per plot (kg)	Projected seed yield (qha^{-1})	Projected oil yield (Lha^{-1})
T_1	84.61^{c}	1375.14	1.86^{ab}	8.16^{bc}	18.56^{c}	11.52^{bcd}	2.48^{bc}	0.49^{bc}	4.96^{bc}	1.83
T_2	86.78^{bc}	1540.89	1.83^{b}	9.86^{ab}	24.26^{b}	10.70^{cd}	3.00^{b}	0.60^{b}	6.00^{b}	2.81
T_3	89.83^{bc}	1410.66	1.83^{b}	9.79^{ab}	21.71^{bc}	12.79^{bc}	2.79^{bc}	0.55^{bc}	5.58^{bc}	2.18
T_4	95.68^{b}	1904.01	1.78^{b}	11.66^{a}	28.99^{a}	14.45^{b}	3.49^{b}	0.69^{b}	6.98^{b}	3.63
T_5	90.83^{bc}	1636.20	1.89^{ab}	9.95^{ab}	22.93^{bc}	13.02^{bc}	3.03^{b}	0.60^{b}	6.06^{b}	2.71
T_6	105.28^{a}	2007.51	2.07^{a}	12.29^{a}	32.98^{a}	18.42^{a}	4.31^{a}	0.86^{a}	8.61^{a}	4.48
T_7	68.56^{d}	1123.40	2.03^{a}	6.87^{c}	18.46^{c}	9.39^{d}	2.08^{c}	0.41^{c}	4.17^{c}	1.98
S. Em (±)	2.97	145.98	0.05	0.85	1.38	0.89	0.25	0.05	0.51	0.36
C.D (P=0.05)	9.28	NS	NS	NS	4.30	2.78	0.78	0.15	1.56	1.11

[T_1- 40: 40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_2- 40:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_3- 60:40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_4- 60:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_5- 80:40:0 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_6 -80:40:20 NPK kg ha^{-1} + FYM 20 t ha^{-1}, T_7-70:50:0(NPK)]

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