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Effect of Nitrogen and Phosphorus on Growth and Yield of Cumin Black (*Nigella sativa* L.) under Terai Zone of West Bengal

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ABSTRACT

An experiment entitled Effect of Nitrogen and Phosphorus on Growth and yield of Cumin Black (*Nigella sativa* L.) under Terai Zone of West Bengal was carried out during the winter season of 2019-20 at Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, India with 5 levels of nitrogen and phosphorus provided through fertilizer (Urea and SSP, respectively). Various growth and yield attributes differed significantly with different levels of nitrogen, plant height (87.09 cm), number of pods per plant (29.44), number of seeds per pod (84.71) and test weight of seeds (5.24 g) was highest in N_5 (120 kg N/ha) but the number of primary branches (8.01) and seed yield (835.32 t/ha) was maximum in N_4 (90 kg N/ ha). Likewise different level of phosphorus exhibited significant difference, while plant height (94.76 cm), number of primary branches (8.61) and test weight of seeds (5.49 g) was highest in P_5 (80 kg P_2O_5/ha) other parameters such as number of pods per plant (32.68), number of seeds per pod (88.64) and seed yield (962.02 t/ha) was found to be maximum in P_4 (60 kg N/ha).The maximum gross returns (Rs 189027.00/ ha), net returns (Rs 96677.00/ha) and B:C ratio (2.05) were recorded under the treatment combination N_4P_4 (90 kg N/ha along with 60 kg P_2O_5/ha).

Keywords Cumin black, Nitrogen, Phosphorus, Terai zone, Yield.

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INTRODUCTION

An annual flowering plant, cumin black (*Nigella sativa* L.) conventionally known as kalaunji or kala jeera is an important minor seed spices and medicinal plant. It belongs to the Ranunculaceae more commonly referred to as a buttercup family. The crop is native to the Mediterranean region but today it is copiously cultivated in various parts of the World: Europe, Egypt, Ethiopia, India, Iraq, Iran, Pakistan, Saudi Arabia, South Syria and Turkey (Jamir *et al*. 2021). In India; Assam, Andhra Pradesh, Bihar, Himachal Pradesh, Jharkhand, Jammu and Kashmir, Madhya Pradesh, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal are the major producer of cumin black (Sultana *et al*. 2018).

Small black colored, dicotyledonous, trigonus and slightly aromatic matured seeds (Gashaw 2020) are mainly traded as a commercial product. The seeds contain 30-35 % of oil which is an essential component of pharmaceutical, perfumery and food industries (Abadi *et al*. 2021).The seeds of cumin black have been a part of herbal medicine for more than 2000 years, such as in Ayurveda, Siddha, Unaniand other traditional medicine systems all over the world (Padmaa 2010).The seeds and their extracts have antimicrobial, antitumor, antidiabetic, antihypertensive, antihistaminic, anti-inflammatory, galactagogue and insect repellent effects (Ali *et al*. 2015). It is effective against many ailments caused by bacteria, viruses, and common allergies (Faravani *et al*. 2012). It can also be used for treating stone in bladder and kidneys (Gupta 2010). The pharmacological properties of cumin black are attributed to the presence of quinine compounds.

In West Bengal it is cultivated in an area of 1520 ha with a production of 1505 metric tonnes. The average yield of cumin black is low which could be due to the poor nutrient management along with the disease incidence and pest infestation. In plants nutrition is one of the most important factors that increase the production. Hence, the appropriate use of chemical fertilizers enhances the growth and quality of plants further, chemical fertilizers are easy to apply, readily absorbed and utilized by the crops.

Agricultural soils are often deficient in Nitrogen but, among the major elements nitrogen has the largest effect on plant physiology and crop growth (Ali *et al*. 2015). In plants all the fundamental processes necessitates protein, of which nitrogen is an integral part. Thus to improve production, nitrogen application is crucial. Its judicious application enhances the vegetative growth, yield, quality of seeds (Izgi 2020) and promotes the uptake and utilization of other inputs efficiently (Bloom 2015). Next to nitrogen the most influential nutrient that boosts up the performance and quality of a plant is Phosphorus (Shirmohammadi *et al*. 2014). It is a vital element of nucleic acids and ATP, the "energy unit" of plants thus, it is a source of energy to energize various cellular endergonic processes. Application of phosphorus aids in seed germination, root development, flower initiation, fruit and seed development. To this end, phosphorus is needed at all developmental stages, from germination till maturity (Malhotra *et al*. 2018). However, today there is a scanty information available pertaining to optimum dose of nitrogen and phosphorus fertilizers. Sen *et al*. (2019) updated that in Terai zone of West Bengal viz., Cooch Behar, commonly followed doses of nitrogen and phosphorus is 30:40 kg ha^{-1}. Therefore, the present study was undertaken to study the effect of various doses of nitrogen and phosphorus on growth and yield of Cumin black under Terai zone of West Bengal.

MATERIALS AND METHODS

The experiment was executed during the year 2019-20 at the Instructional farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal, India, which falls under the Terai zone. Geographically the experimental area is situated at 26°19'86" N latitude and 89°23'53" E longitude. The experiment was laid out in Factorial Randomized Block Design and was replicated three times using variety Rajendra Shyama. The sowing was done in the middle of November in the raised bed of size 2 m X 1.5 m following the spacing of 30 cm X 10 cm. Two factors i.e., Nitrogen and Phosphorus was the main subject of this study. Nitrogen in the form of Urea was applied in 5 levels; N_1 (0 kg N/ha), N_2 (30 kg N/ha), N_3(60 kg N/ha), N_4 (90 kg N/ha), N_5 (120 kg N/ha) similarly, Phosphorus in the form of Single Super Phosphate (SSP) was also applied in 5 levels; P_1 (0 kg P_2O_5/ha), P_2 (20 kg P_2O_5/ha), P_3 (40 kg P_2O_5/ha), P_4 (60 kg P_2O_5/ha), P_5 (80 kg P_2O_5/ha). From five randomly selected plants per plot observations were made on plant height (cm), number of primary branches, number of pods per plant, number of seeds per pod, seed yield (t/ha) and test weight of seeds. The data were statistically analyzed (Gomez and Gomez 1984) and the significance of different sources of variations was tested by Fisher and Snedecor's 'F' test with probability at 0.05%. Critical difference was tested at 5% level of significance (Fisher and Yates 1963). Finally, the cost of cultivation (Rs/ha) of each treatment was estimated considering the expenditure of inputs, charges for cultivation, labor and other charges.

RESULTS AND DISCUSSION

Plant height

The plant height was significantly affected by the various doses of nitrogen and phosphorus fertilizers

(Table 1). The height of the plants escalated as the level of the dose was raised. The maximum height of 87.09 cm was reached in cumin black when the nitrogen at the rate of 120 kg/ha (N_5) was applied. The height noticeably reduced as the dose of nitrogen reduced with the minimum height being 82.17 cm when no source of nitrogen (N_1) was given. Tuncturk *et al*. (2011) readdressed that the height of cumin black could range from 27.9 cm to 95.1 cm. Plant height is a genetic trait, also environmental factors play a major role. In this experiment, the increase in height could have been governed by both of the factors along with the effect of nitrogen application. As, the application of nitrogen is known to increase plant growth by promoting processes such as cell division, cell enlargement and various metabolic processes (Ali *et al*. 2015).

In like manner, tallest plants with the height of 94.76 cm was obtained when the dose of phosphorus was maximum 80 kg/ha (P_5) in the experiment and the lowest height of 74.15 cm in treatment P_1. The increase in plant height with increased dose of phosphorus was also reported by Sultana *et al*. (2019). Since, phosphorus is a part of ATP which is required for the biosynthesis of many plant bio molecules, also it modifies the activity of various enzymes by phosphorylation which could have been the reason for increasing height with increasing dose of phosphorus. Similarly, Yimam *et al*. (2015), proclaimed that among the various doses of nitrogen and phosphorus the tallest plant were obtained from treatment with the highest rate of nitrogen and phosphorus application. This result is further supported by the findings of Rana *et al*. (2012), who reported the similar outcomes of nitrogen and phosphorus doses.

Table 1. Effect of varying level of nitrogen and phosphorus on plant height, number of primary branches and number of pods per plant of Cumin black.

Treatments	Plant height (cm)	Number of primary branch	Number of pods per plant
5 levels of nitrogen (N)			
N_1 (0 kg/ha)	82.17	7.68	26.64
N_2 (30 kg/ha)	83.60	7.77	27.52
N_3 (60 kg/ha)	84.92	7.84	28.53
N_4 (90 kg/ha)	86.00	8.01	29.21
N_5 (120 kg/ha)	87.09	7.99	29.44
SEm±	0.36	0.05	0.23
CD (P=0.05)	1.02	0.14	0.64
5 levels of phosphorus (P_2O_5)			
P_1 (0 kg/ha)	74.15	6.87	21.81
P_2 (20 kg/ha)	80.96	7.49	26.44
P_3 (40 kg/ha)	84.72	7.91	29.36
P_4 (60 kg/ha)	89.20	8.41	32.68
P_5 (80 kg/ha)	94.76	8.61	31.05
SEm±	0.36	0.05	0.23
CD (P=0.05)	1.02	0.14	0.64
Interaction			
SEm±	0.80	0.11	0.50
CD (P=0.05)	NS	NS	1.44

Number of primary branches

Comparative effect of various levels of nitrogen and phosphorus on the number of primary branches in cumin black has been depicted in Table 1. The maximum number of primary branches 8.01 was obtained when nitrogen at the rate of 90 kg/ha (N_4) was applied however, when the dose was further raised to 120 kg/ha there was a deduction in the number of primary branches per plants. It suggests that 90 kg/ha of nitrogen was more optimum at the present growing condition of the crop. This outcome is in accord with Özgüven and Şekeroğlu (2007) who reported that the maximum number of branches was obtained with the nitrogen dose of 90 kg/ha. Nitrogen is an important nutrient that improves vegetative parts hence optimum and regular availability of nitrogen might have improved the branching ability and production of vegetative buds (Sultana *et al*. 2019).

There was a positive influence of increasing level of phosphorus on the number of primary branches. The maximum primary branches of 8.61 was obtained in plants treated with 80 kg/ha (P_5) of phosphorus, while in control (P_1) only 6.87 numbers of primary branches was reported. The higher primary branches with higher application rate of phosphorus could be due to the availability of right amount of Pin plants bettering the cell division and promoting the higher branches number. The result is in line with Yimam *et al*. (2015) who also received highest number of primary branches with highest dose of phosphorus application.

Number of pods per plant

Number of pods per plant was significantly influenced by the various levels of nitrogen and phosphorus fertilizer (Table 1). Cumin black receiving the highest dose of nitrogen 120 kg/ha (N_5) certainly produced highest number of pods per plant i.e., 29.44. At the same time plots receiving the 0 nitrogen (N_1) produced the least amount of pods per plant i.e., 26.64 per plant. Ali *et al*. (2015) and Rana *et al*. (2012) also reported increase in pods number per plants of cumin black with increasing dose of fertilizer levels. The present studies revealed higher number of pods than the previous researchers' results. It is possible due to the appropriate climatic condition, sufficient nitrogen availability which led to the improvement in their branches number and their height further escalating pods production.

As for the phosphorus effect on the number of pods per plants, it is evident from Table 1 that the dose of 60 kg/ha (P_4) showed the most positive effect with highest pods number of 32.68 per plant followed by 31.05 pods per plant in dose of 80 kg/ha (P_5).The higher number of pods per plant in increasing dose of phosphatic fertilizer could be attributed to the effect on vigour of plant and number of leaves, while less number of pods per plant in P_1 (0 kg/ha) is probably due to the deficient of nutrition in control treatment. Tuncturk *et al*. (2011) also reported that increasing phosphorus levels increased the number of pods in cumin black.

Table 2. Effect of varying level of nitrogen and phosphorus on number of seeds per pod, seed yield (kg/ha) and test weight of seeds (g) of Cumin black.

Treatments	Number of seeds per pod	Seed yield (kg/ha)	Test weight of seeds (g)
5 levels of nitrogen (N)			
N_1 (0 kg/ha)	80.00	752.66	4.99
N_2 (30 kg/ha)	81.40	772.73	5.08
N_3 (60 kg/ha)	82.83	798.01	5.16
N_4 (90 kg/ha)	83.99	835.32	5.21
N_5 (120 kg/ha)	84.71	834.63	5.24
SEm±	0.26	2.21	0.01
CD (P=0.05)	0.75	6.29	0.03
5 levels of phosphorus (P_2O_5)			
P_1 (0 kg/ha)	74.77	639.98	4.67
P_2 (20 kg/ha)	78.20	674.16	4.86
P_3 (40 kg/ha)	83.43	803.91	5.20
P_4 (60 kg/ha)	88.64	962.02	5.46
P_5 (80 kg/ha)	87.88	913.30	5.49
SEm±	0.26	2.21	0.01
CD (P=0.05)	0.75	6.29	0.03
Interaction			
SEm±	0.59	4.93	0.02
CD (P=0.05)	1.69	14.07	0.06

Number of seeds per pod

From the Table 2 it is ascertained that the dose of nitrogen at the rate of 120 kg/ha (N_5) provided with the maximum number of seeds per pods i.e., 84.71 followed by 83.99 seeds per pod with nitrogen dose 90 kg/ha (N_4). The influence of lower dose of nitrogen was signified with lesser number of seeds per pod, least being in nitrogen dose of 0 kg/ha (N_1). El-Leithy *et al*. (2019) and Rana *et al*. (2012) also presented similar effect of increasing the seeds number along with increasing dose of nitrogen in cumin black plants.

Data presented in Table 2 revealed that phosphorus at the rate of 60 kg/ha (P_4) was more effective in improving the number of seeds per pod (88.64) while plants with no application of phosphorus (P_1) proved to have the pods with least number of seeds (74.77). The increase in number of seeds per pod with increasing rate of phosphorus fertilizer application could be due to the fact that phosphorus is an integral part in seed formation as it plays significant role in protein synthesis, phospholipids and phytin all of which are essential in the formation of seeds (Rahman *et al*. 2008).

Seed yield (kg/ha)

The experiment revealed that highest seed yield (kg/ha) of 835.32 kg/ha was obtained from the nitrogen application of 90 kg/ha (N_4) followed by 834.63 kg/ha in treatment N_5 (120 kg/ha). It is apparent from the Table 2 that seed yields increased with increasing fertilizer levels up to 90 kg/ha and then it decreased. Tuncturk *et al*. (2012) and Özgüven and Şekeroğlu (2007) also concluded that application of nitrogen increases seed yield, but at higher doses it will have negative effects on the seed yield. The lowest seed yield of 752.66 kg/ha was obtained from control treatment N_1 (0 kg/ha) in this experiment. Seed yield is directly affected by other components like number of branches and capsules which was found to be satisfactorily high in treatment N_4. Further application of nitrogenous fertilizer helps in increasing the protein content in plants and it makes plants greener and plays a vital role in boosting the crop yield (Khan *et al*. 2008). Similar trend of increasing grain yield with the increase of fertilizer level was also reported by Ali *et al*. (2015).

Effect of various levels of phosphorus was in accordance with the effect of nitrogenous fertilizer application. Referring Table 2 it is evident that seed yield of cumin black increased with elevated dose of phosphorus up to 60 kg/ha (P_4) then at higher dose of 80 kg/ha (P_5) the yield dwindled. Similarly, Tuncturk *et al*. (2011) found increasing yield with increasing phosphorus fertilizer levels. The increase in yield with increased supply of nitrogen and phosphorus could be due to more luxurious plant growth resulting in higher leaf and higher rate of photosynthesis, finally improving the pods setting thereby resulting in higher seed yield (Yimam *et al*. 2015).

Test weight of seeds (g)

Referring to Table 2 the effect of various level of nitrogen on test weight of cumin black seeds can be interpreted. The nitrogen dose of 120 kg/ha (N_5) showed highest test weight of 5.24 g followed by 5.21 gin 90 kg/ha nitrogen dose (N_4). El-Leithy *et al*. (2019) also found highest test weight of cumin black seeds in nitrogen dose of 100 kg/ fed and lowest was in control. Test weight of seed is affected by a wide range of factors like variety, growing conditions, climatic factors and soil properties (Tuncturk *et al*. 2011). Previous studies on the effect of nitrogen fertilizer on test weight of seeds were reported to be 2.4 g- 2.6 g (İzgi 2020) and 2.81 g- 3.54 g (Tulukcu 2015).

As for the various level of phosphorus, 80 kg/ha (P_5) provided the maximum test weight of 5.49 g which was at par with 5.46 g in dose of 60 kg P/ha (P_4). On the other hand lowest test weight was obtained in treatment devoid of phosphorus fertilizer P_1 (0 kg/ha). Özgüven and Şekeroğlu (2007) also found an increase in thousand seed weight by increasing phosphorus levels. Phosphorus application increases the dry matter production which results in greater partitioning of dry matter to pods thereby improving the seed size (Demeke *et al*. 2020).

Effect of varying level of nitrogen and phosphorus on cost benefit ratio

The economics of cultivation of cumin black under different levels of nitrogen and phosphorus has been presented in Table 3. Among the various treatment combinations, highest gross returns of Rs 189027.00/ha, net return of Rs 96677.00/ha and benefit cost ratio 2.05 was obtained from N_4P_4 (90 kg N/ha along with 60 kg P_2O_5/ha) combination, followed by N_5P_4 (120 kg N/ha along with 60 kg P_2O_5/ha) wherein gross returns of Rs 185275.80/ha, net return of Rs 92595.80/ha and benefit cost ratio 2.00 was achieved. The least gross returns of Rs 111837.60/ha was obtained from

Table 3. Economics of cultivation of cumin black under different levels of nitrogen and phosphorus.
N_1 (0 kg nitrogen/ha), N_2 (30 kg nitrogen /ha), N_3 (60 kg nitrogen /ha), N_4 (90 kg nitrogen /ha), N_5 (120 kg nitrogen /ha) and P_1 (0 kg phosphorus/ha), P_2 (20 kg phosphorus /ha), P_3 (40 kg phosphorus /ha), P_4 (60 kg phosphorus /ha), P_5 (80 kg phosphorus /ha).

Treatment combinations	Seed yield (kg/ha)	Cost of cultivation (Rs)	Gross return Benefit (Rs)	Net rerun (Rs)	Benefit : Cost
$N_1 P_1$	621.32	83235	111837.60	28602.60	1.34
$N_1 P_2$	642.53	87610	115655.40	28045.40	1.32
$N_1 P_3$	769.09	89485	138436.20	48951.20	1.55
$N_1 P_4$	866.16	91360	155908.80	64548.80	1.71
$N_1 P_5$	864.17	93235	155550.60	62315.60	1.67
$N_2 P_1$	628.66	86065	113158.80	27093.80	1.31
$N_2 P_2$	656.39	87940	118150.20	30210.20	1.34
$N_2 P_3$	782.91	89815	140923.80	51108.80	1.57
$N_2 P_4$	905.26	91690	162946.80	71256.80	1.78
$N_2 P_5$	890.45	93565	160281.00	66716.00	1.71
$N_3 P_1$	648.19	86395	116674.20	30279.20	1.35
$N_3 P_2$	670.66	88270	120718.80	32448.80	1.37
$N_3 P_3$	800.06	90145	144010.80	53865.80	1.60
$N_3 P_4$	959.20	92020	172656.00	80636.00	1.88
$N_3 P_5$	911.93	93895	164147.40	70252.40	1.75
$N_4 P_1$	664.95	86725	119691.00	32966.00	1.38
$N_4 P_2$	689.56	88600	124120.80	35520.80	1.40
$N_4 P_3$	823.05	90475	148149.00	57674.00	1.64
$N_4 P_4$	1050.15	92350	189027.00	96677.00	2.05
$N_4 P_5$	948.90	94225	170802.00	76577.00	1.81
$N_5 P_1$	636.77	87055	114618.60	27563.60	1.32
$N_5 P_2$	711.63	88930	128093.40	39163.40	1.44
$N_5 P_3$	844.43	90805	151997.40	61192.40	1.67
$N_5 P_4$	1029.31	92680	185275.80	92595.80	2.00
$N_5 P_5$	951.03	94555	171185.40	76630.40	1.81

treatment combination N_1P_1 (without N and P_2O_5) whereas the least net return of Rs 27093.80/ha and benefit cost ratio, 1.31, respectively was obtained in treatment combination N_2P_1 (30 kg N/ha along with 0 kg P_2O_5/ha).

CONCLUSION

On the basis of the seed yield potential and benefit cost ratio of cumin black in this present investigation, it may be suggested that the treatment combination of N_4P_4 (90 kg N/ha along with 60 kg P_2O_5/ha) was found good for the cumin black production in the terai zone of West Bengal.

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