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Effect of different doses of NPK fertilizer on yield characters of nigella (*Nigella sativa* L.)

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Abstract
Nigella is a small herb growing to a height of 45 to 55 cm. The seeds of black cumin are of economic importance, used both as a seed spice and also for medicinal purposes. Leaves are capillary, pinnatisect, 2.5 to 5.0 cm long, cut into numerous fine linear, lanceolate, segments, not involucrating the flower. Effect of Nitrogen, Phosphorus & potassium on morphological characters of Nigella under Mandsaur region of Madhya Pradesh. Among the yield and yield attributes application of different levels of NPK showed the significant variations expect harvest index (%), oil content in seed (%). However, T_8 - 70:70:55 kg ha^{-1} NPK was registered with highest value of number of capsules plant^{-1} (77.13), number of seeds capsules^{-1} (106.87), seed yield g plant^{-1} (19.69), seed yield q ha^{-1} (10.24), biological yield q/ha (43.09), test weight (3.17 g), harvest index (27.91%) and oil content in seed (0.46%) compared to T_1 - 40:20:20 kg ha^{-1} NPK (recommended dose).

Keywords: Nitrogen, phosphorus & potassium, nigella, yield attributing character

Introduction
Nigella (*Nigella sativa* L.) also known as *Kalaunji* is a seed spice having an immense pharmacological potential. It belongs to the family Ranunculaceae having chromosome number 2n = 12. It has many regional names like Kalajira, Nalla jilakara, Karunjiragam and called as black cumin, black seed or small fennel in English. The crop is native to the Mediterranean region of Turkey and Cyprus (Davis, 1965) and has been used by various cultures and civilizations for millennia. It is an annual spice that has originated from arid and semi-arid zones and is used widely in traditional and industrial pharmacology. One of the most important constituents of volatile oil of the nigella seeds are thymoquinone. Thymoquinone belongs to class of compounds known as terpenoids (Varun *et al.*, 2020) [7].

In India, it is commercially cultivated in Punjab, Himachal Pradesh, Madhya Pradesh, Rajasthan, Jharkhand, Assam, West Bengal and Andhra Pradesh (Vijay and Malhotra, 2002) [8]. It is mostly cultivated in Mandsaur, Neemuch and Shajapur districts of Madhya Pradesh.

The seeds contain a yellowish volatile oil in the range of 1.5 per cent and fatty oil from 36 to 38 per cent, as well as protein, sugar, mucus, organic acids, toxic glucosides, tannins, resins, proteins, saponins, arabic acid and others soluble in alcohol organic acids. Free amino acids such as cystine, lysine, aspartic acid, glutamic acid, alanine, tryptophan, valine and leucine are present in dormant seeds (Lindley, 1981).

The dried black seeds of nigella are the commercial product being used in food, flavor and medicines. The essential oil from nigella seed has also demand in the pharmaceutical and perfumery industry. The main alkaloids present in nigellin seeds are nigellidine, nigellicine, nigelline they have anticarcinogenic properties. The carboxylic compound, nigell one, is an important component with medicinal and conservative properties. Nigella seeds have been used since ancient times as a spice in the preparation of pickles, as one of the ingredients. The seeds are sprinkled as a preservative between the folds of linen and woolen fabric to prevent insect attacks. The oil can be used as a stabilizer for edible fats. Seeds are aromatic, diuretic, diaphoretic, antibilous, stomachic, stimulant and carminative, digestive, anthelmintic, galactagogue and emmenagogue (Nadakarni, 1976) [2].

Plant nutrition is one of the most important factors in increasing plant productivity. Nitrogen (N) is best known in plants due to its presence in the structure of a protein molecule. Accordingly, N plays an important role in the synthesis of plant components by various enzymes (Khalid and Shedeed, 2015). The availability of nitrogen is of paramount importance for plant cultivation, as it is the main and irreplaceable component of protein and nucleic acid molecules (Troug, 1973). Adequate nitrogen is associated with vigorous vegetative growth,

and more efficient use of available resources ultimately leads to increased productivity.

Potassium (K) is an essential macronutrient and the most abundant cation in higher plants.K has been the target of some researchers mainly because it is required for enzyme activation (Khalid and Shedeed, 2015). Potash fertilizers are an indispensable component for reducing the severity of diseases in nigella plants. Application of 30 kg K / ha together with 30 kg N / ha reduced plant death due to disease and also increased caraway yields (Champawat and Pathak, 1982).

Material and Methods

The field experiment entitled "Effect of NPK on growth, yield and quality of nigella (*Nigella sativa* L.)" was conducted during the *rabi* season of 2020-2021. The field experiment was carried out at the "Horticulture Research Farm", department of Plantation, Spices, Medicinal and Aromatic crops, College of Horticulture, Mandsaur, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior (M.P.) during *rabi* season of 2020-2021. The College of Horticulture, Mandsaur is situated in Malwa plateau in Western part of Madhya Pradesh. This region falls under agro climatic zone No.10 of the State. The research experiment was enclosing in a randomized block design with three replications and nine treatments and analyzed from OP statistics software.

Table 1: Treatment details

S. No	Treatment details
T_1	NPK – 40:20:20 Kg/ha
T_2	NPK – 40:30:25 Kg/ha
T_3	NPK – 50:40:30 Kg/ha
T_4	NPK – 50:50:35 Kg/ha
T_5	NPK – 60:55:40 Kg/ha
T_6	NPK – 60:60:45 Kg/ha
T_7	NPK – 70:65:50 Kg/ha
T_8	NPK – 70:70:55 Kg/ha
T_9	NPK – 80:75:60 Kg/ha

Fig 1: View of experimental field of nigella

Result

Yield parameters

Number of capsules plant^{-1}

The magnitude of increase in data of number of capsules plant^{-1} was significantly influenced by the application of different level of NPK. It is elucidated in the data presented on Table 2 and graphically illustrated on Fig.2 the data further indicates that the number of capsules plant^{-1} were significantly influenced and the maximum data was recorded under treatment T_8 – 70:70:55 kg/ha NPK (77.13) followed by T_7 – 70:65:50 kg/ha NPK (75.40) and they were at par with each other but appreciably superior over rest of the treatments. T_1 – 40:20:20 kg/ha (recommended dose) was relatively recorded with minimum number of capsules plant^{-1} (49.73).

Number of seeds capsules^{-1}

The number of seeds capsules^{-1} were recorded with a magnitude of variation and was significantly influenced by the application of different level of NPK. It is presented in Table 2 and graphically illustrated in Fig. 3. The data displayed that T_8 – 70:70:55 kg/ha NPK show statistically superior result (106.87) compare to rest of the treatments which was at par with T_7 – 70:65:50 kg/ha NPK (103.20) but was significantly superior over the rest of the treatments. Though, treatment T_7 – 70:65:50 kg/ha NPK (103.20) was found the second highest which was at par with T_9 – 80:75:60 kg/ha NPK (101.20) but was significantly higher over remaining treatments. T_1 – 40:20:20 kg/ha (recommended dose) was relatively recorded with minimum number of seeds capsules^{-1} (82.93).

Seed yield (g plant^{-1})

The data seed yield (g plant^{-1}) was significantly influenced by the application of different level of NPK. The data are presented in Table 2 and diagrammatically illustrated in Fig. 4. The findings presented that the maximum seed yield (g plant^{-1}) was recorded under treatment T_8 – 70:70:55 kg/ha NPK (19.69) was significantly superior among the treatments. The least seed yield (g plant^{-1}) (4.13) was recorded under T_1 – 40:20:20 kg/ha (recommended dose).

Seed yield (q ha^{-1})

The data related to seed yield (q ha^{-1}) was significantly influenced by the application of different level of NPK. The data are presented in Table 2 and graphically illustrated in Fig. 5. A perusal of data indicated the significantly maximum seed yield (10.24 q ha^{-1}) was recorded under the treatment T_8 – 70:70:55 kg/ha NPK which was at par with T_7 – 70:65:50 kg/ha NPK (9.80) but appreciably highest over the remaining treatments. Though, T_7 – 70:65:50 kg/ha NPK (9.80) was lagged behind the former which was at par with T_9 – 80:75:60 kg/ha NPK (9.54) and T_6 - 60:60:45 kg/ha NPK (9.34) but was superior over the rest of the treatments. However, minimum seed yield (q ha^{-1}) (6.68) was observed under T_1 – 40:20:20 kg/ha NPK (recommended dose).

Biological yield (q ha^{-1})

The magnitude of increase in data of biological yield (q ha^{-1}) was significantly influenced by the application of different level of NPK. It is elucidated in the data presented on Table 2 and graphically illustrated on Fig. 9. An examination of data showed that the maximum biological yield (q ha^{-1}) was recorded under treatment T_8 – 70:70:55 kg/ha NPK (43.09) which was statistically at par with T_7 – 70:65:50 kg/ha NPK (38.87) but significantly highest over the other treatments. Though, treatment T_7 – 70:65:50 kg/ha NPK (38.87) was found second highest which was at par with T_9 – 80:75:60 kg/ha NPK (37.17) and T_6 – 60:60:45 kg/ha NPK (35.72) but significantly higher over remaining treatments. The minimum biological yield (28.16 q ha^{-1}) was observed under T_1 – 40:20:20 kg/ha NPK (recommended dose).

Harvest index (%)

The harvest index was recorded with a magnitude of variation and was shown non-significant variation by the application of

different level of NPK. It is presented in Table 2 and graphically illustrated in Fig. 6. The statistically recorded data displayed that T_8 – 70:70:55 kg/ha NPK show non-significantly superior result (27.91) compare to rest of the treatments followed by T_7 – 70:65:50 kg/ha NPK (27.34) and T_9 – 80:75:60 kg/ha NPK (27.06). T_1 – 40:20:20 kg/ha (recommended dose) was relatively recorded with least harvest index (23.74).

Test weight (g)

The data of test weight (g) was significantly influenced by the application of different level of NPK. The data are presented in Table 3 and graphically illustrated in fig 7. Data revealed that, T_8 – 70:70:55 kg/ha NPK was recorded statistically maximum test weight (3.17) which was at par with T_7 – 70:65:50 kg/ha NPK (2.85) but significantly superior over other treatments. Though, T_7 – 70:65:50 kg/ha NPK (2.85) was found second highest and which was at par with T_9 – 80:75:60 kg/ha NPK (2.72) and T_6 – 60:60:45 kg/ha NPK (2.60) but appreciably superior over other treatments. The least test weight (2.08) was recorded under T_1 – 40:20:20 kg/ha NPK (recommended dose).

Oil content in seed (%)

The data related to oil content in seed (%) shown statistically non-significant variation by the application of different level of NPK. The data are presented in Table 3 and graphically illustrated in Fig. 8. A critical examination of data showed that the application of different level of NPK has maximum oil content in seed of nigella in T_8 – 70:70:55 kg/ha NPK (0.46) followed by T_7 – 70:65:50 kg/ha NPK (0.44) and T_9 – 80:75:60 kg/ha NPK (0.43). The least Oil content in seed (0.39) was recorded under T_1 – 40:20:20 kg/ha NPK (recommended dose)**.**

Economics of the treatment of nigella production

In the present investigation economics of various treatment benefits cost ratio was affected with the application of different levels of NPK. The net profit from the cultivation of nigella was calculated substracting the cost of cultivation from gross returns. The data are presented in Table 4.10. Economics analysis indicated that the best treatment in term of net return was obtained in T_8 – 70:70:55 kg/ha NPK (Rs. 154920.00) followed by T_7 – 70:65:50 kg/ha NPK (Rs.147200.00) and T_9 – 80:75:60 kg/ha NPK (Rs.142775.00). However, in terms of B:C ratio was in T_8 – 70:70:55 kg/ha NPK (5.27:1) followed by T_7 – 70:65:50 kg/ha NPK (5.04:1) and T_9 – 80:75:60 kg/ha NPK (4.93:1). While, the lowest was recorded in T_1 – 40:20:20 kg/ha NPK (Rs. 91740) net return and (3.22:1) B:C ratio.

Discussion

The experimental data exhibited all the yield and yield attributing parameters varied significantly during different growth stages except harvest index (%), oil content in seed (%).

Result revealed that the highest number of capsules plant^{-1} (77.13) was recorded in treatment T_8 – 70:70:55 kg/ha NPK while, least number of capsules plant^{-1} (49.73) was recorded in T_1 – 40:20:20 kg/ha NPK. The number of capsules increased by increasing doses of phosphorus, and they produced more capsules. The number of capsules is directly affected by number of branches. Under optimal growing conditions, plants can produce more fruitful branches. In addition to optimal growing conditions, additional nutrient application helps to increase the number of branches and capsules on the plant. Ozgyuven and Şekeroğlu 2007 reported that increasing phosphorus levels increase the number of capsules in black cumin. Similar finding was obtained by Tuncturk *et al*., 2011 [5].

The maximum number of seeds capsules^{-1} (106.87) was observed in T_8 – 70:70:55 kg/ha NPK while, least number of seeds capsules^{-1} (82.93) was observed in T_1 – 40:20:20 kg/ha NPK. The number of seeds in the capsule is the capacity of the plant reservoir. Plants retain photosynthetic material and ultimately lead to an increase in biomass. Plant height, number of capsules per plant, and number of seeds per capsules are good indicators of seed yield by Yimam *et al*., 2015 [9].

The investigation revealed that treatment T_8 – 70:70:55 kg/ha NPK showed the maximum seed yield g plant^{-1} (19.69) while, lowest (4.13) was observed under T_1 – 40:20:20 kg/ha NPK. The application of phosphate fertilizers had a significant effect on the seed yield, the more fertilizer produced higher seed yields. The seed yield increases with the increase in the amount of fertilizer this finding was given by Tuncturk *et al.*, 2011 [5].

The highest seed yield q ha^{-1} (10.24) was recorded under T_8 – 70:70:55 kg/ha NPK. Whereas, lowest (6.68) was recorded under T_1 – 40:20:20 kg/ha NPK. An increase in seed yield when interacting with fertilizers may be associated with the synthesis of more chlorophyll for photosynthesis, which promotes plant development. This finding was given by Ashraf *et al.*, 2005 and similar result was given by Yimam *et al.*, 2015 [9]. Increased yields may also be associated with the role of fertilizers in improving the absorption of nutrients by the root system, increased chlorophyll content, photosynthesis activity and protein content in cultivated plants given by Rana *et al*., 2012 [4].

In this experiment, the superior biological yield q/ha (43.09) was observed under T_8 – 70:70:55 kg/ha NPK. While, least (28.16) was recorded under T_1 – 40:20:20 kg/ha NPK. An increase in the biological yield of black cumin in response to an increased amount of combined NPs may be associated with more luxurious plant growth, more leaves, and a higher rate of photosynthesis, which could cause the formation of many pods, which led to a higher growth in the number of pods, resulting in higher yields. This result is also confirmed by Ozguven and Sekeroglu 1997 [3] and Ashraf *et al*., 2005 and similar finding by Yimam *et al.*, 2015 [9].

Result revealed that the test weight was superior (3.17 g) in treatment T_8 – 70:70:55 kg/ha NPK. While, least (2.08 g) was recorded under T_1 – 40:20:20 kg/ha NPK. Variation in a test weight due to a wide range of factors such as diversity, growing conditions, climatic factors and soil properties affect the weight of a thousand seeds given by Yimam *et al*., 2015 [9].

The statistical data revealed that, T_8 – 70:70:55 kg/ha NPK was recorded with maximum harvest index (27.91%). While, least (23.74%) was recorded under T_1 – 40:20:20 kg/ha NPK. This indicated that grain crops are strongly forced in favour of seed yield and their harvest index can increase. Adequate nitrogen can be associated with vigorous vegetative growth and efficient use of available nutrients, which can ultimately lead to higher yields. Das *et al*., 1992 and similar finding by Yimam *et al*., 2015 [9].

The maximum oil content in seed was found maximum in T_8 – 70:70:55 kg/ha NPK (0.46%). While, least (0.39%) was recorded under T_1 – 40:20:20 kg/ha NPK. Oil content depends on crop varieties and regional environmental conditions as well as on growing techniques, fertilizer application, and frequency andextent of irrigation by Ashraf *et al.*, 2006 [1].

Economics of the treatments

The gross return, net return and benefit cost ratio was enhanced by the application of different level of NPK. The maximum net returns (Rs.154920.00) and B:C ratio (5.27:1) was recorded in treatment in T_8 -70:70:55kg/ha NPK while, the lowest inT_1 – 40:20:20 kg/ha NPK. (Rs. 91740.00) net returns and (3.22:1) B: C ratio. Thus, it can be concluded that higher doses of N and P have more yield and quality of AN-1 as well as highest return per hectare by Rana *et al.*, 2012 [4]. recorded at 45, 90 DAS and at harvest. The main findings of the investigation are summarized below.

Table 2: Effect of different levels of NPK on number of capsules plant^{-1} and number of seeds capsules^{-1}, seed yield (g plant $^{-1}$), Seed yield (q $^{ha-1}$), Biological yield (q ha -1), Harvest index (%) in nigella

Treatments	Number of capsules plant^{-1}	Number of seeds capsules^{-1}	Seed yield (g plant^{-1})	Seed yield (q ha^{-1})	Biological yield(q ha^{-1})	Harvest index (%)
T_1 - NPK – 40:20:20 Kg/ha	49.73	82.93	4.13	6.68	28.16	23.74
T_2 - NPK – 40:30:25 Kg/ha	51.90	86.40	5.62	7.17	29.53	24.57
T_3 - NPK – 50:40:30 Kg/ha	57.80	88.33	7.29	7.83	31.52	25.21
T_4 - NPK – 50:50:35 Kg/ha	61.80	91.80	9.10	8.45	32.87	25.81
T_5 - NPK – 60:55:40 Kg/ha	63.87	96.87	11.12	9.03	34.22	26.31
T_6 - NPK – 60:60:45 Kg/ha	67.80	98.80	13.35	9.34	35.72	26.85
T_7 - NPK – 70:65:50 Kg/ha	75.40	103.20	17.68	9.80	38.87	27.34
T_8 - NPK – 70:70:55 Kg/ha	77.13	106.87	19.69	10.24	43.09	27.91
T_9 - NPK – 80:75:60 Kg/ha	72.27	101.20	15.89	9.54	37.17	27.06
S.Em (±)	1.15	1.10	0.21	0.07	0.42	1.18
CD (5%)	0.64	0.20	0.64	0.20	1.26	3.53

Table 3: Effect of different levels of NPK on Test weight (g), Oil content in seed (%) in nigella

Treatments	Test weight (g)	Oil content in seed (%)	Total cost	Yield (q ha^{-1})	Gross return	Net profit
T_1 - NPK – 40:20:20 Kg/ha	2.08	0.39	28500.00	6.68	120240.00	91740.00
T_2 - NPK – 40:30:25 Kg/ha	2.15	0.40	28650.00	7.17	129060.00	100410.00
T_3 - NPK – 50:40:30 Kg/ha	2.21	0.41	28750.00	7.83	140940.00	112190.00
T_4 - NPK – 50:50:35 Kg/ha	2.31	0.42	28790.00	8.45	152100.00	123310.00
T_5 - NPK – 60:55:40 Kg/ha	2.44	0.42	28850.00	9.03	162540.00	133690.00
T_6 - NPK – 60:60:45 Kg/ha	2.60	0.43	28900.00	9.34	168120.00	139220.00
T_7 - NPK – 70:65:50 Kg/ha	2.85	0.44	29200.00	9.80	176400.00	147200.00
T_8 - NPK – 70:70:55 Kg/ha	3.24	0.46	29400.00	10.24	184320.00	154920.00
T_9 - NPK – 80:75:60 Kg/ha	2.72	0.43	28945	9.54	171720	142775.00

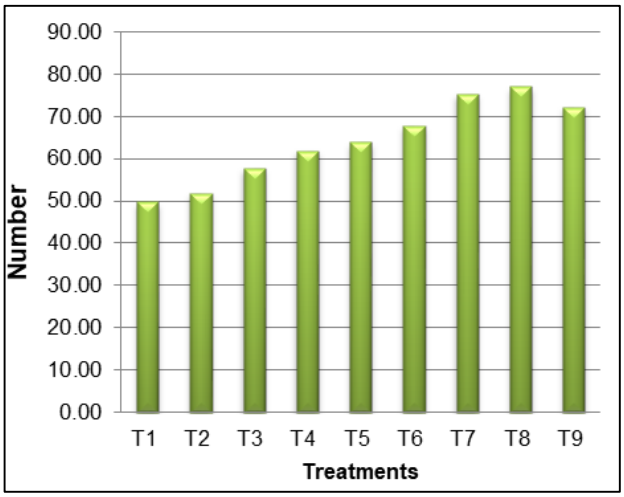

Fig 2: Effect of different levels of NPK on number of capsules plant^{-1}

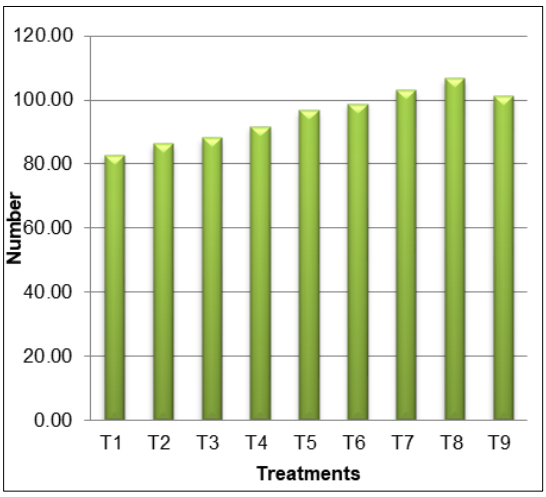

Fig 3: Effect of different levels of NPK on number of seeds capsules^{-1}

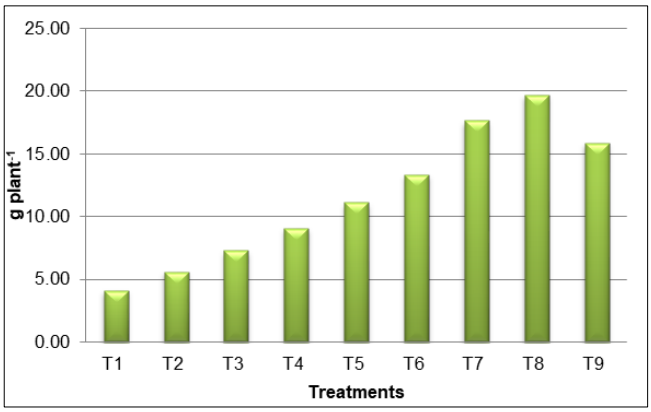

Fig 4: Effect of different levels of NPK on seed yield (g plant^{-1})

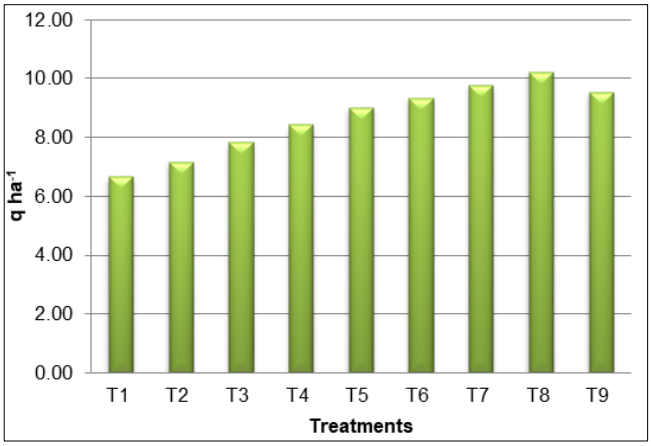

Fig 5: Effect of different levels of NPK on seed yield (q ha^{-1})

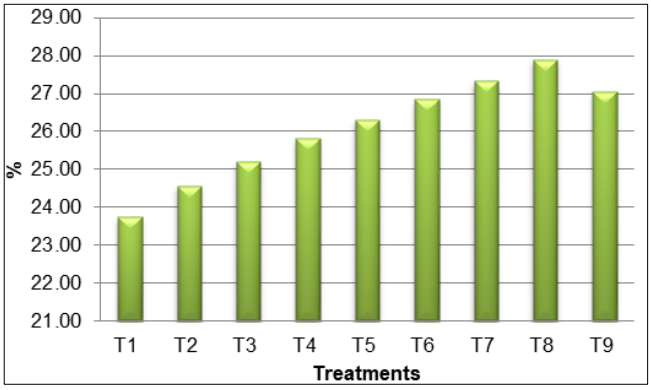

Fig 6: Effect of different levels of NPK on harvest index (%)

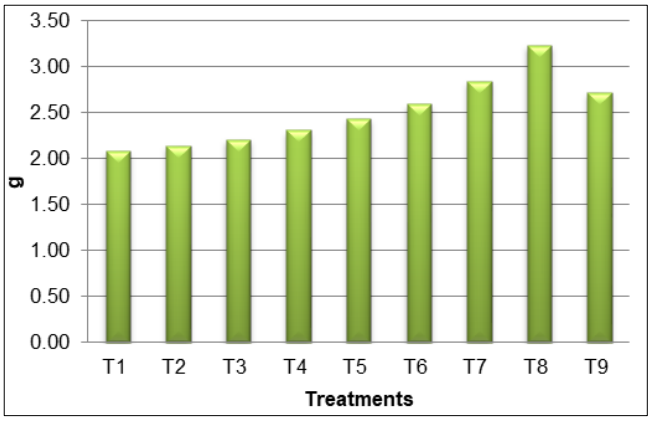

Fig 7: Effect of different levels of NPK on test weight (g)

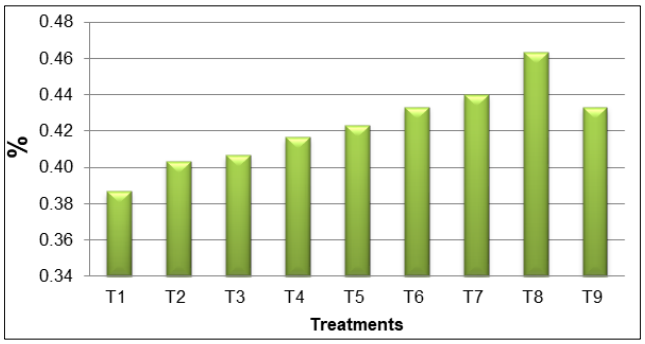

Fig 8: Effect of different levels of NPK on oil content in seed (%)

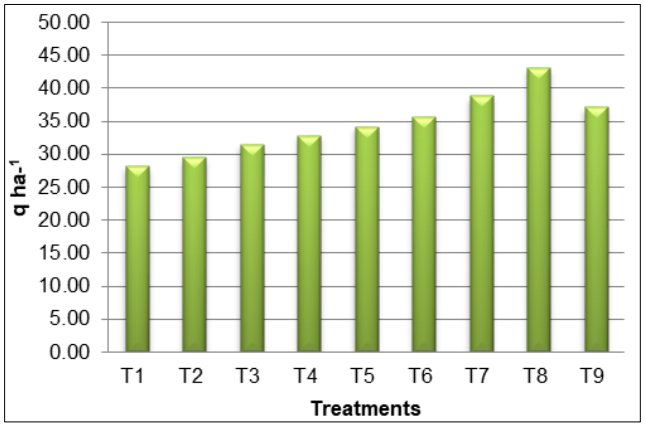

Fig 9: Effect of different levels of NPK on biological yield (q ha-1)

Summary

Among the yield and yield attributes application of different levels of NPK showed the significant variations expect harvest index (%), oil content in seed (%). However, T_8 - 70:70:55 kg ha^{-1} NPK was registered with highest value of number of capsules plant^{-1} (77.13), number of seeds capsules^{-1} (106.87), seed yield g plant^{-1} (19.69), seed yield q ha^{-1} (10.24), biological yield q/ha (43.09), test weight (3.17 g), harvest index (27.91%) and oil content in seed (0.46%) compared to T_1 - 40:20:20 kg ha^{-1} NPK (recommended dose). Under the economics of the treatment, it was found that the highest net returns (Rs.154920.00) and benefit cost ratio (5.27:1) were obtained from T_8 - 70:70:55 kg ha^{-1} NPK. randomized block design with three replications and nine treatments. All the parameters were recorded at 45, 90 DAS and at harvest. The main findings of the investigation are summarized below.

Conclusion

On the basis of one year research and the results reported above it could be concluded that the different levels of NPK significantly and non-significantly influenced the growth and yield attributes of nigella. Hence, out of nine treatments T_8 - 70:70:55 kg ha^{-1} NPK was best comprises for enhanced growth and yield of nigella.

Suggestion for further work

Based on the current study, the following line of work may be suggested for future investigation

1. The same experiment may be repeated for the confirmation of result of present work.
2. Same experiment can be repeated with more varieties and different locations.

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