Influence of bioformulation on growth, yield and quality of black cumin (*Nigella sativa* L.)

ABSTRACT

*Nigella sativa*L commonly known asBlack cumin. is an annual, herbaceous spice crop belonging to the family Ranunculaceae. It is an annual herb possessing wide range of medicinal uses apart from its commercial significance as a spice-yielding plant. Black cumin is used in folk (herbal) medicine all over the globe for the treatment and prevention of a number of diseasesA field investigation entitled "Influence of Bioformulation on Growth, Yield, and Quality of Black Cumin (*Nigella sativa* L.)" was carried out during the rabi seasons of 2020-21 and 2021-22 at the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Vishwavidyalaya, Nadia, West Bengal. The study employed six different treatments and five replications, arranged in a Randomized Block Design.The treatments composed of T_1 (Panchagavya foliar spray @ 4%), T_2(Panchagavya foliar spray @ 8%), T_3(Panchagavya foliar spray @ 12%), T_4(Panchagavya foliar spray @ 16%), T_5(Panchagavya foliar spray @ 20%) and T_6 (Control) were evaluated.Among treatment T_5 (Panchagavya as foliar spray @ 20%) recorded the maximum plant height of 29.95cm, 60.45cm and 73.09cm respectively at 60,90 and 120 DAS, the maximum number of primary branches and secondary branches of 7.18/plant and 24.54/plant were recorded at 120 DAS. Highest projected seed yield of 566.39 kg/ha along with highest dry pod weight (0.32g) pod diameter (0.93cm), seed yield/plant (2.62g), 1000 seed weight (2.10g) along with the maximum essential oil content (1.06%) and highest B:C ratio of 1.88 with a highest net return of Rs.52982/ha recorded under the same treatment. T_4 (Panchagavya as foliar spray @ 16%) recorded 2nd highest plant height of 29.51cm, 59.26cm and 72.71 cm at 60,90 and 120 DAS and 2nd highest Projected seed yield of 547.73 kg/ha with other characters like dry pod weight (0.30g), pod diameter (0.92cm), seed yield/plant (2.09g) and 1000 seed weight (2.09g) along with essential oil content of 1.01% and 2nd highest cost benefit ratio of 1.84 and net return of Rs.49850/ha which were at par with T_5(Panchagavya foliar spray at 20%).

Keywords: Black cumin, FYM, panchagavya, yield

INTRODUCTION

Nigella sativa L commonly known as Black cumin is an annual, herbaceous spice crop belonging to the family Ranunculaceae. It is commonly called 'Kare jirage' in Kannada, 'Kalonji' or 'Kalajira' in Hindi, 'Karunjiragam' in Sanskrit and is also

called as black seed or small fennel in English. Originally native to the Mediterranean region, it has since spread to Africa, Europe, and Asia. In India, it is commercially cultivated in West Bengal, Assam, Punjab, Himachal Pradesh, Madhya Pradesh, Bihar, Jharkhand, and Andhra Pradesh. The crop is estimated to cover approximately 9,000 hectares and produce about 7,000 to 8,000 tons annually in India(Huchchannanavar*et al.*,2019).

Organic farming is gaining gradual momentum across the world, growing awareness of health globally has led to the demand for organically produced seed spices which are nil from pesticide residues and health hazards. The export of seed spices from India constitutes a significant portion of the country's overall spice exports, with seed spices accounting for 28% in volume and 18% in value. This segment of the spice market is experiencing a growing demand, particularly for organic seed spices, driven by heightened health awareness in both developed and developing countries. This trend reflects a broader global shift towards organic and health-conscious food products. People are ready even to pay 15-20 % higher prices for organic products. The mindset of the people gradually changed towards organic farming in the hope of getting a better price of quality food being produced in the system. Today, the yield and quality of plant production are gradually decreasing due to the factors that cause stress in agricultural areas. Moreover, it is imperative to increase the overall yield and nutritional quality to feed the increasing population. Environmental pollution, salinity, drought, excessive and unconscious use of chemicals, etc. are most important sources of stress. These factors cause both the deterioration of the fertile soil structure and the negative effects on the yield and other yield elements of the plants.The application of bioformulations offers several remarkable advantages, including its sustainable nature, plant probiotic properties, and long-term viability, positioning it as a promising technology for the future organic agriculture.

Material and methods

A field experiment (Rabi seasons of 2020-21 and 2021-22) was conducted at the Horticultural Research Station, Mondouri and the laboratory of the Department of Plantation, Spices, Medicinal and Aromatic crops, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal (22.94551203753782, 88.53351785151352). The experimental material composed of 6 different doses of

panchagavyaas foliar spray black Cumin at 30 DAS, 60 DAS and 90 DAS.The treatments composed of T_1 (Panchagavya foliar spray @ 4%), T_2(Panchagavya foliar spray @ 8%), T_3(Panchagavya foliar spray @ 12%), T_4(Panchagavya foliar spray @ 16%), T_5(Panchagavya foliar spray @ 20%) and T_6 (Control) were evaluated, in randomized block design with 4 replications. The experiment at the field comprised of Gangetic Alluvial sandy clay loam soil , welldrained, good water holding capacity with moderate soil fertility status (Sand- 54.25%, Silt- 30.20%, Clay-14.30%, pH-5.74, Organic carbon (%)- 0.85, N (kg/ha) – 207, P2O5(kg/ha)- 380.1, K2O (kg/ha)- 526.6, S (mg/ha) - 60.18, Zn (mg/ha)- 1.66, Ca (mg/ha)- 949.55, B (mg/ha)- 0.44). Well rotten FYM @ 10 t ha^{-1} was applied during field preparation as basal application and mixed well with the soil, no chemical fertilizers were applied. The entire experimental field was levelled and then divided into 30 plots of 1.8m × 2.5 m in size with 1 m isolation distance between plots. Seeds of the black cumin variety Rajendra Shyama were sourced from Rajendra Agricultural University, Bihar, and treated with Trichoderma viride at a rate of 4 g/kg. Each year, the seeds were sown in the first week of November with a spacing of 30 cm x 10 cm at a rate of 6 kg/ha. The plots were irrigated immediately after sowing, with subsequent irrigations provided every 8-10 days based on soil moisture levels. Treatments were administered according to the established schedule in the respective plots.Randomly selected five tagged plants from each plot were considered for recording the growth parameters like plant height(cm), number of primary and secondary branches and dry matter accumulation (g $plant^{-1}$). The following yield parameters like fresh and dry pod weight (g), pod diameter (cm), 1000 seed weight(g), plot yield(g) and projected yield (kg ha^{-1}) were also recorded. Harvesting was done during the first fortnight of March of each year based on the climatic conditions of that time. The quality parameters, such as essential oil content, were measured through hydro distillation using a Clevenger apparatus. The cost of cultivation was determined by considering the input prices at the time of their use. Gross income was calculated by multiplying the yield by the current market price of the seed.Fisher's method of analysis of variance, as outlined by Sundararaj*et al.* in 1972, was employed for analyzing and interpreting the data. The significance level for the 'F' test was set at P = 0.05, and critical difference (CD) values were calculated when the 'F' test yielded significant results.

Plate 1. Preparation of panchagavya

Plate 2. General view of experimental plot

RESULTS AND DISCUSSION

Table 1. Effect of panchagavya on plant height of black cumin

Treatment	Plant height(cm)			
	Days after sowing			
	30	60	90	140
T_1	6.11	27.85	58.44	71.01
T_2	6.73	27.75	56.80	70.67
T_3	6.10	27.57	58.47	71.44
T_4	6.29	29.51	59.26	72.71
T_5	6.15	29.95	60.45	73.09
T_6	5.78	25.64	56.09	67.04
S.Em (±)	**0.18**	**0.63**	**0.69**	**0.62**
C.D. (P=0.05)	**0.53**	**1.87**	**2.03**	**1.82**

(T_1 - Panchagavya foliar spray @ 4%,T_2 - Panchagavya foliar spray @ 8%,T_3 - Panchagavya foliar spray @12%,T_4 - Panchagavya foliar spray @ 16%,T_5 - Panchagavya foliar spray @ 20%, and T_6– Control)

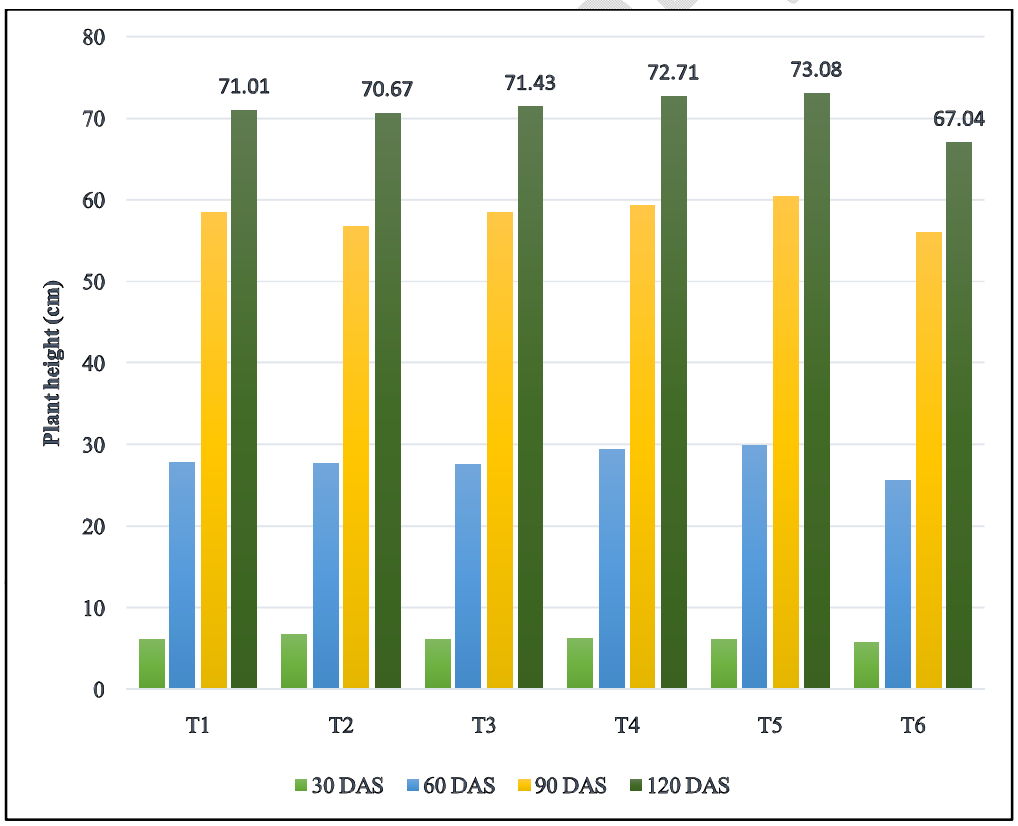

Fig.1 Effect of panchagavya on plant height of black cumin at different stages of growth.

Table 2. Effect of panchagavya on number of primary and secondary branches/plant and dry matter accumulation of black cumin at 120 DAS.

Treatment	Number of primary branches/plant	Number of secondary branches/plant	Dry matter accumulation /plant(g)
T_1	6.92	22.48	16.42
T_2	7.16	23.86	16.28
T_3	6.90	23.80	16.30
T_4	7.02	24.48	17.10
T_5	7.18	24.54	18.62
T_6	5.74	19.34	16.12
S.Em(±)	**0.18**	**0.58**	**0.39**
C.D.(P=0.05)	**0.53**	**1.71**	**1.14**

(T_1 - Panchagavya foliar spray @ 4%,T_2 - Panchagavya foliar spray @ 8%,T_3 - Panchagavya foliar spray @12%,T_4 - Panchagavya foliar spray @ 16%,T_5 - Panchagavya foliar spray @ 20%, and T_6– Contro

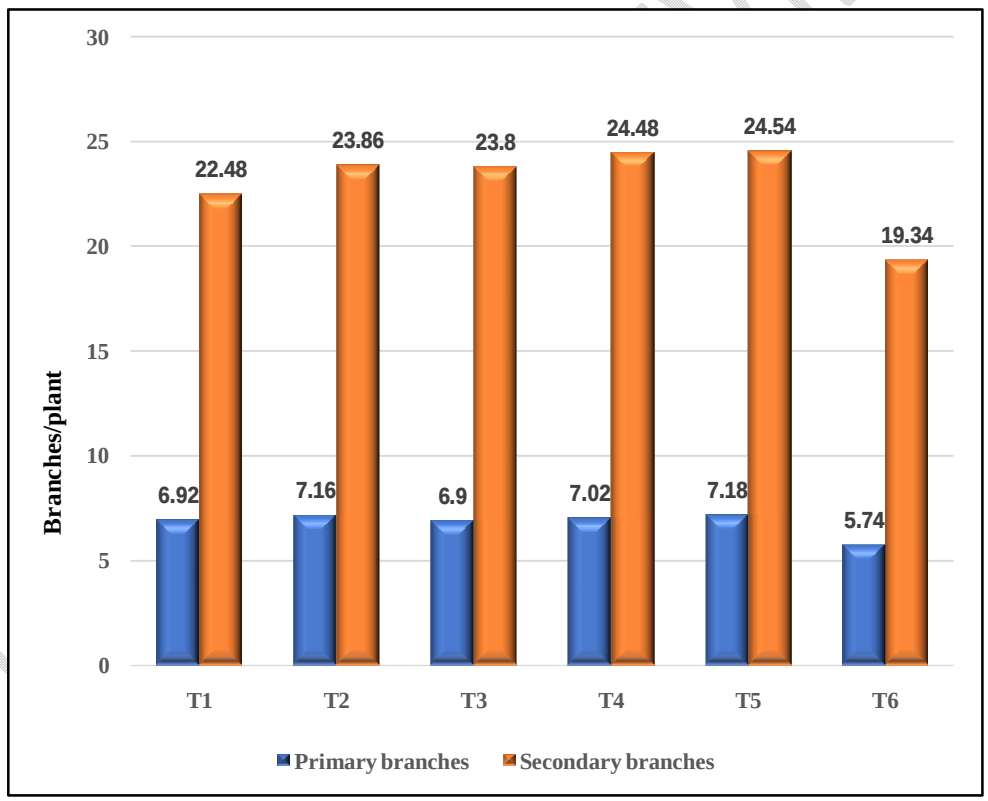

Fig. 2 Effect of panchagavya on number of primary and secondary branches/plant of black cumin at 120 DAS.

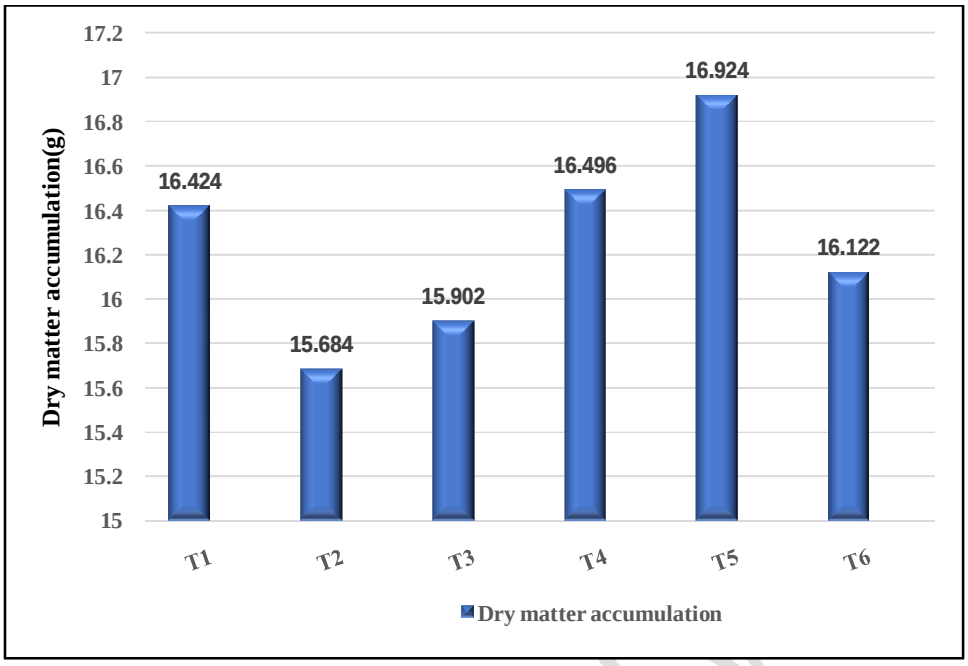

Fig. 3 Effect of panchagavya on dry matter accumulation at 120 DAS, in black cumin.

Growth parameters

Data presented in Table 1 and Fig. 2 on plant height of black cumin as influenced by panchagavya indicated that at 30 DAS, just before treatments were imposed the plants in the plot marked as T_2 recorded maximum of 6.73cm andminimum of 5.40cm as initial data byT_{10}. At 60 DAS, maximum plant height of 29.95 cm was recorded in T_5(Panchagavya foliar spray @ 20%) and this treatment was on par with T_4 (Panchagavya foliar spray at 16%) which was 29.51 cm and minimum of 25.64 cm under T_6. At 90 DAS also T_5 (Panchagavya foliar spray at 20%) resulted a highest plant height of 60.45cm and this was on par with T_4 (Panchagavya foliar spray at 16%) which was 59.26cm and least (56.09cm) in control. At the time of harvest the same treatment T_5 (Panchagavya foliar spray at 20%) recorded highest height of 73.09cm and this was on par with T_4 (Panchagavya foliar spray at 16%) which was 72.71cm and lowest was found in T_6 (67.04 cm).The number of primary and secondary branches/plant (Table 2 and Fig. 2) at 120 DAS of black cumin indicated that maximum 7.18 number of primary branches/plants were recorded in T_5 followed by T_2 (7.16) and T_4 (7.02) whereas, T_6 recorded a minimum primary branch of 5.74 numbers only. Maximum number of secondary branches/plant (24.54) were observed in T_5 (Panchagavya foliar spray at 20%) and this was on par with T_4 (Panchagavya foliar spray at 16%) which was 24.48.

The number of primary branches was recorded minimum of 19.34 in T_6 (control) only. The highest Dry matter accumulation was seen in T_5which was 16.92g at 120 DAS and it was on par with the treatment T_4 (6.50g), minimum was (16.12 g)in control.

Table 3. Effect of panchagavya on fresh pod weight, dry pod weight and pod diameter black cumin.

Treatment	Fresh pod weight(g)	Dry pod weight(g)	Pod diameter(cm)
T_1	1.24	0.29	0.91
T_2	1.22	0.27	0.90
T_3	1.26	0.30	0.92
T_4	1.29	0.30	0.92
T_5	1.30	0.32	0.93
T_6	1.22	0.27	0.89
S.Em (±)	**0.01**	**0.02**	**0.01**
C.D. (P=0.05)	**0.09**	**0.05**	**0.03**

(T_1 - Panchagavya foliar spray @ 4%,T_2 - Panchagavya foliar spray @ 8%,T_3 - Panchagavya foliar spray @12%,T_4 - Panchagavya foliar spray @ 16%,T_5 - Panchagavya foliar spray @ 20%, and T_6– Control).

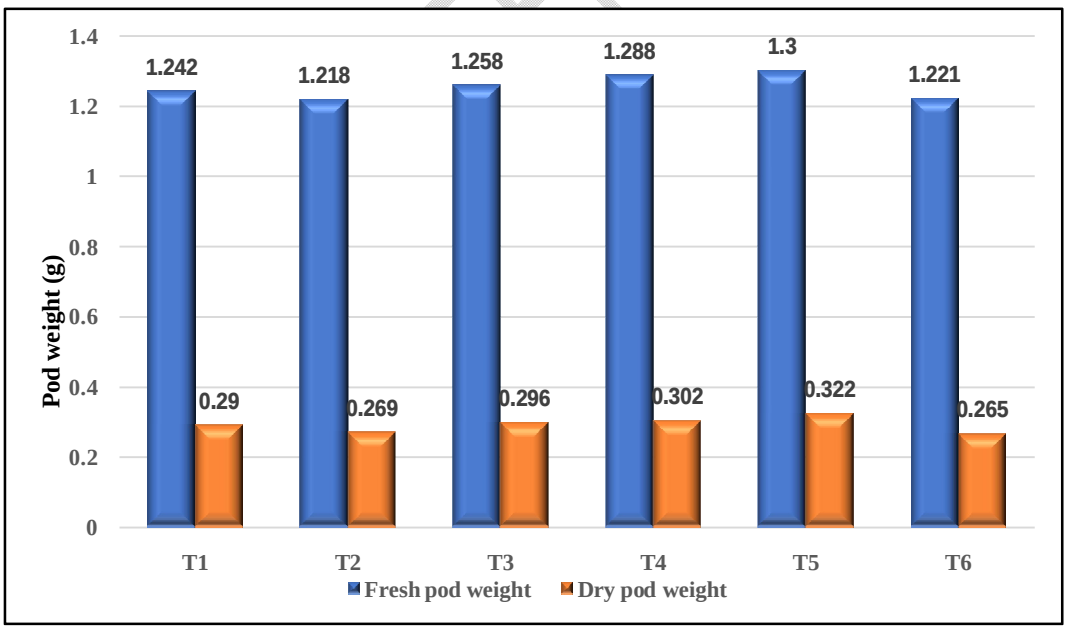

Fig. 4 Effect of panchagavya on fresh pod and dry pod weight of black cumin.

Table4. Effect of panchagavya on the, seed yield/plant, seed yield/plot, 1000 seed weight, Projected seed yield/ha, %increase in yield and essential oil content in black cumin.

Treatment	Yield/ Plant (g)	Yield/ plot (g)	1000 seed Weight (g)	Projected seed yield (kg/ha)	Increase in yield (%)	Essential oil %
T_1	2.38	255.40	1.98	454.04	23.82	0.91
T_2	2.24	260.90	2.09	463.82	31.70	0.96
T_3	2.46	282.20	2.02	501.68	42.45	0.97
T_4	2.53	308.10	2.09	547.73	55.52	1.01
T_5	2.62	318.60	2.10	566.39	60.82	1.06
T_6	1.94	198.10	1.89	352.17	-	0.86
S.Em (±)	**0.10**	**12.62**	**0.05**	**22.45**	-	**0.07**
C.D.(P=0.05)	**0.30**	**37.25**	**0.17**	**66.23**	-	**0.21**

(T_1 - Panchagavya foliar spray @ 4%,T_2 - Panchagavya foliar spray @ 8%,T_3 - Panchagavya foliar spray @12%,T_4 - Panchagavya foliar spray @ 16%,T_5 - Panchagavya foliar spray @ 20%, and T_6– Control)

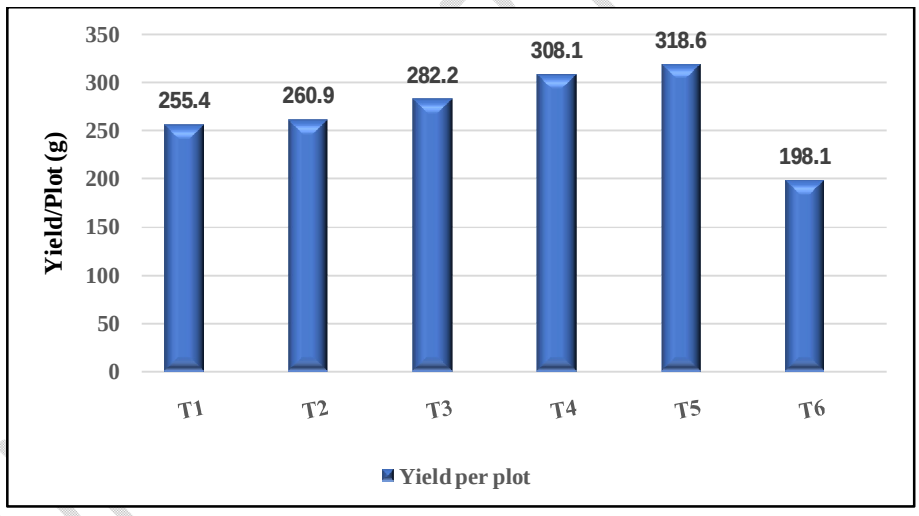

Fig.5 Effect of panchagavya on the seed yield/plot, in black cumin

Yield parameters

The data presented in Table 3 and illustrated in Fig. 4 on fresh pod weight, dry pod weight and pod diameter indicated that highest fresh pod weight of 1.30g was recorded in T_5 (Panchagavya foliar spray @ 20%) followed by T_4 (Panchagavya foliar spray @ 16%) with 1.29g which were significantly at par with each other and minimum pod weight of 1.22g inT_6.T_5recorded highest dry pod weight of 0.32g and this was on

par with T_4 which was 0.30g and the minimum dry weight in T_6 (0.27g) only. No significant differences were observed in pod diameter among different treatments.

Data presented in Table 4 on effect of panchagavya on seed yield/plant as revealed that, among the treatments T_5 recorded a significantly higher seed yield of 2.62g/plant followed by T_4 (2.53g)/plant. The lowest seed yield of 1.94g was recorded under control plots.T_5 recorded a maximum seed yield of 318.60g/plot and this was on par with T_4 (308.10g) and lowest seed yield of 198.10g/plot was obtained in control. T_5 recorded a significantly higher 1000 seed weight of 2.10g and this was on par with T_4) with 2.09g and minimum weight of 1.89g in T_6. Seed yield/hectare differed significantly among the treatments. T_5 (Panchagavya foliar spray @ 20%) recorded the highest projected seed yield of 566.39kg/hectare and this was on par with T_4 (547.73kg)and T_3 (501.68kg), respectively. The lowest seed yield of 352.17kg/ha was recorded in T_6 only. Increase in yield (%)with respect to control, T_5 recorded the highestincrease in yield of 60.82% and 2nd highest was 55.52% in T_4.

QUALITY PARAMETERS

The data presented in Table 4on the effect of Panchagavya on the essential oil content of black cumin indicated that there was no significant difference among the treatments. The highest essential oil content of 1.06% was recorded in T_5 and lowest in T_6 (0.86%).

Table 5. Effect of panchagavya on economics of black cumin cultivation.

Treatment details	Cost of cultivation (Rs. / ha)	Gross income (Rs. / ha)	Net returns (Rs. / ha)	B:C ratio
T_1	57896	90808	32912	1.57
T_2	58496	92764	34268	1.59
T_3	59096	100336	41240	1.70
T_4	59696	109546	49850	1.84
T_5	60296	113278	52982	1.88
T_6	51392	70434	19042	1.37

(T_1 - Panchagavya foliar spray @ 4%,T_2 - Panchagavya foliar spray @ 8%,T_3 - Panchagavya foliar spray @12%,T_4 - Panchagavya foliar spray @ 16%,T_5 - Panchagavya foliar spray @ 20%, and T_6– Control)(Diesel-Rs.89.8/*l*,FYM-Rs.600/ton, Man days-Rs.328/day,panchagavya-Rs.30/*l*, seed cost-Rs.200/kg).

ECONOMICS

From the data, presented in table 5 on economics of black cumin cultivation indicated that, T_5 recorded the highest B:C ratio of 1.88 with a highest net return of Rs.52982/ha, followed by T_4 (1.84. and Rs. 49850, respectively) and control recorded lowest B:C ratio of 1.37 and net return of Rs.19042/ha, respectively.

Discussion

Panchagavya consistently improved all growth parameters of black cumin. Application of Panchagavya as a foliar spray at 20% significantly enhanced various growth metrics: plant height at 60, 90, and 120 days after sowing (DAS) measured 29.95 cm, 60.45 cm, and 73.09 cm, respectively; the number of primary and secondary branches per plant at 120 DAS reached 7.18 and 24.54, respectively; and dry matter accumulation at 120 DAS was 18.62 g. At a 16% concentration, Panchagavya resulted in plant heights of 29.51 cm, 59.26 cm, and 72.71 cm at 60, 90, and 120 DAS, respectively; the number of primary and secondary branches per plant at 120 DAS were 7.02 and 24.48; and dry matter accumulation at 120 DAS was 17.10 g.

The observed increase in growth parameters can be attributed to the application of Panchagavya, which enhances root and shoot length, fresh and dry weight of seedlings, plant height, and chlorophyll content. Additionally, it improves the availability of macro and micro nutrients such as Zn, Cu, and Mn, and increases microbial activity (Jain et al. 2013). The growth enzymes in Panchagavya likely facilitated rapid cell division and multiplication, contributing to the enhanced growth characteristics and increased plant height. Sanjutha *et al.* (2008) highlighted that foliar spraying with Panchagavya promotes plant growth due to its rich content of beneficial nutrients, growth hormones, and biofertilizers.

Foliar spray of Panchagavya @ 20% recorded significantly increased yield attributes such as fresh pod weight (1.30g), dry pod weight (0.32g) and pod diameter (0.93cm), 1000 seed weight (2.10g)seed yield/plant (2.62g) and projected seed yield/hectare (566.39 kg/ha) and Panchagavya as foliar spray @ 16% recorded fresh pod weight (1.29g), dry pod weight (0.30g) and pod diameter (0.92cm), , 1000 seed weight (2.09 g), seed yield/plant (2.09g) and projected seed yield/hectare (547.73 kg/ha) (Table-4) which may be due to the positive effect of Panchagavya on plants at a certain

concentration. These findings are also in accordance with the findings of Kumar *et al*. (2011 and Swain*et al*., 2015).where they also recorded that application ofpanchagavya as foliar spray increases the physiological growth, leaf area index, dry matter production, chlorophyll content, N content, yield, yield attributes and ultimately the economics. They also reported that panchagavya is a rich source of several plant essential nutrients. Hence, application of this liquid organics provides balanced nutrition to the crop. Growth hormones present in these liquid organic manures help in better root development, mineral absorptions, photosynthesis and easy assimilation of nutrients which ultimately increases crop yield.

The highest essential oil content, recorded at 1.06%, was observed with Panchagavya foliar spray at 20%, while a content of 1.02% was noted with Panchagavya foliar spray at 16%. These findings align with Kumar and Singh (2020), who reported that Panchagavya significantly enhances various growth attributes, including fruit number, fruit weight, seed and pod length, girth, oil content, and overall yield in a range of crops.

Analysis of the data on gross returns revealed significant variations across different treatments. The highest net returns of Rs. 52,982 per hectare and a benefit-cost ratio of 1.88 were achieved with the T5 treatment, likely due to the higher yield resulting from spraying Panchagavya at 20%. This increased yield contributed to the higher net returns for this treatment.

The preparation of Panchagavya is straightforward, which reduces input costs, while its application results in high net returns and an improved benefit-cost ratio for farmers. Additionally, Panchagavya is safe, eco-friendly, and supports sustainability (Saini *et al*., 2022).

CONCLUSION

It can be concluded that the growth, yield, and quality of black cumin can be enhanced by soil application of Panchagavya at a concentration of 16% at 30, 60, and 90 days after sowing.The results from this study highlight a promising potential for future research to enhance both the production and quality of organic black cumin.Future research could focus on intensive, long-term studies examining the combined effects of various bioformulations, methods, timing of application, and physiological and meteorological interactions.

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