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Effect of organic manures on growth and yield of fennel under Garhwal valley conditions

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Abstract
The present study is titled "Effect of Organic Manures on Growth and Yield of Fennel under Garhwal Valley Conditions. It was carried out at the Research Farm of the Department of Seed Science and Technology, Chauras Campus, H.N.B Garhwal University, Srinagar (Garhwal), Uttarakhand during *Rabi* 2020-21 India. *Foeniculum vulgare*, commonly known as fennel, is a widely recognized and essential medicinal and aromatic plant from the Apiaceae family. This study also examines the impact of organic fertilizers in fennel cultivation, highlighting their potential to improve soil structure and microbial biomass. Organic fertilizers, derived from both animal and plant sources, are considered eco-friendly alternatives with long term benefits. Results from the study indicate that FYM, particularly at a rate of 25 tons ha^{-1}, significantly enhanced plant height, root length, primary branches, and fresh and dry weights at both 90 and 120 days after sowing. The maximum secondary branches and seed yield (12.87 q ha^{-1}) was recorded in T_4 (Vermicompost 9 ton ha^{-1}) at Garhwal valley condition. These findings suggest the potential of organic manures to improve the growth and yield of funnel. In conclusion, this provides an extensive overview of funnel, addressing its botanical characteristics, chemical composition, pharmacological attributes, traditional uses, and agricultural practices. The experimental data highlights the positive impact of organic manures on fennel growth parameters, offering valuable insights for sustainable cultivation practices.

Keywords: Farm yard manure, vermicompost, root length, yield attributes, irrigation and leaf length

1. Introduction
Foeniculum vulgare (Apiaceae) frequently accepted as fennel is an able-bodied accepted and important alleviative and ambrosial bulb broadly acclimated as carminative, digestive, lactogogue and diuretic and in alleviative respiratory and gastrointestinal disorders. Hanif *et al.* (2020) [5] Phenolic compounds isolated from *F. vulgare* are advised to be amenable for its antioxidant action while the airy aroma compounds accomplish it an accomplished flavouring agent. The present assay is an abreast and absolute assay of the chemistry, pharmacology, acceptable uses and assurance of *F. vulgare* (Rather *et al.*, 2016) [14].
Fennel is a cross-pollinated crop from the Apiaceae family. It is a diploid species with 2n=22 chromosomes that originated in Europe (Solanki *et al.*, 2001) [21]. Fennel is an herb with a slender, extendable, smooth stem that grows to be 100-180 cm tall. The inflorescence is terminal, with a complex umbel surrounded by bract involucres. Small, bisexual, complete, typical, and pentamerous flowers. A schizocarp of two mericarps attached to a partitioning carpophore is the typical product known as the seed. A fully formed normal seed measures 4 to 8 mm in length. Fennel capital oil or its accustomed apparatus such as anethole characterize altered activities like antifungal, insecticidal, and antibacterial activity. Fennel possesses antioxidant property, antibacterial activity, anti-inflammatory effect, antiallergic, and hepatoprotective action and antispasmodic activity (Javed *et al.*, 2020) [7].
The seeds have a protein content of 9.5 percent, a fat content of 10.0 percent, a starch content of 42.3 percent, a rough fiber content of 18.5 percent, and a mineral content of 13.4 percent. The seeds contain a variable amount of oil, ranging from 2.5 to 6.5 percent, depending on the genotypes or organic kinds. Seed oil is used for scenting purifiers and flavoring cakes because it is unstable Bernath *et al.* (1996) [1].

The total area under cutivation is around 0.90 lakh hectares, with a yield of 1.57 lakh tonnes and a productivity of 1744.44 kg ha^{-1} (FAOSTAT, 2020) [2].

Organic manures in allegory of the actinic fertilizers accept lower comestible agreeable and are apathetic absolution but they are as able as actinic fertilizers over best periods of use Continuous acceptance of asleep fertilizer affects clay structure. Hence, amoebic manures can serve as another to mineral fertilizers for convalescent clay anatomy and microbial biomass. Organic fertilizers are acquired from beastly sources such as beastly admixture or bulb sources like blooming manure (Lal *et al.*, 2019) [8].

2. Materials and Methods

2.1 Experiment site and treatments

The current field experiment was conducted during *Rabi* season 2020-2021 at the Department of Seed Science and Technology, Chauras Campus, H.N.B. It was carried out at the research farm of Garhwal University, Srinagar (Garhwal), Uttarakhand. India. This area is located at 30° 13 '9" North latitude and 78° '47' 30" East longitude and at an altitude of 540 meters above mean sea level. The climate of the region is humid and subtropical resulting in wet summers and cool winters and major seasons are experienced throughout the year. The annual normal maximum and minimum temperature, relative humidity, and rainfall of the area are 13 to 20°C. Minimum between 5 to 20°C, 60 percent, and 112.9 cm respectively. The field experiment consisted of 6 treatments of organic fertilizers such as three FYM and three vermicompost treatments and 1 single control. The experiment was laid out in RBD comprising 7 treatments and replicated thrice consists of T_1 - 25 ton FYM ha^{-1}, T_2 - 20 ton FYM ha^{-1}, T_3 - 15 ton FYM ha^{-1}, T_4 - 9 ton VC ha^{-1}, T_5 - 7 ton VC ha^{-1}, T_6 - 5 ton VC ha^{-1} and T_7 - Control. Manures were applied 20 days before sowing. RF-25 variety of fennel was used for sowing. Crop management practices were followed as per the recommendation of the area.

2.2 Statistical Analysis

The data recorded were analyzed by using MS Excel, and OPSTAT. The mean values of each replication for all the traits under study were subjected to statistical analysis as per Randomized Complete Block Design (Factorial).

3. Results and Discussion

3.1 Growth parameters at 90 days after sowing

3.1.1 Plant length (cm)

The shoot length data presented in Table 1 revealed that the maximum length (16.86 cm) of the shoot was recorded in T_1 (FYM 25 ton ha^{-1}), which was found to be significantly superior over other treatments, followed by 16.0 cm in T_2 (FYM 20 ton ha^{-1}) and 14.23 cm in T_3 (FYM 15 ton ha^{-1}). The minimum shoot length (11.03 cm) was found in the T_7 control.

3.1.2 Root length (cm)

The root length data presented in Table 1 revealed that the maximum length (5.73 cm) of the root was recorded in T_4 (9 ton ha^{-1} Vermicompost), which was found to be significantly superior over other treatments, followed by 5.46 cm in T_1 (FYM 25 ton ha^{-1}) and 5.16 cm in T_2 (FYM 20 ton ha^{-1}). The treatment T_7 (control) observed a Minimum (3.46 cm) root length.

3.1.3 Number of primary branches $plant^{-1}$

The data clearly showed in Table 1 that there was a significant difference in the number of primary branches $plant^{-1}$. The maximum (9.13) number of primary branches per plant was recorded in T_1 (FYM 25 ton/ha), followed by 8.80 in T_4 (vermicompost 9 ton/ha) and 8.26 in T_6 (vermicompost 5t/ha), while the minimum number (6.53) of primary branches per plant was found in T_7 (control).

3.1.4 Number of secondary branches per plant

Significant variations were observed among all the treatments for a number of Secondary branches per plant as presented in Table 1. The maximum (13.06 cm) number of secondary branches per plant was recorded in T_4 (vermicompost 9 ton/ha), followed by 12.40 in T_1 (FYM 25 ton/ha) and 11.26 in T_2 (FYM 20 ton/ha), while the lowest (9.40) number of secondary branches per plant was found in T_7 (control).

3.1.5 Fresh weight per plant (g)

This is apparent from the data presented in Table 1. The maximum (199.13 g) fresh weight was recorded in T_1 (FYM 25 ton/ha), which was found to be significantly superior to other treatments, followed by 150.13 g in T_4 (Vermicompost 9q/ha) and 141.33g in T_3 (FYM 15 ton /ha). The minimum (75.73g) fresh weight was recorded in T_7 (control).

3.1.6 Dry weight per plant (g)

It is apparent from the data presented in Table 1. The maximum (21.53g) dry weight was recorded in T_1 (FYM 25 ton/ha), which was found to be significantly superior to other treatments, followed by 15.40 g in T_3 (FYM 15 ton/ha), and 14.53 g in T_2 (FYM 20 ton/ha). The minimum (6.53g) dry weight was recorded in T_7 (control).

3.2 Growth parameters at 120 days after sowing

3.2.1 Plant height (cm)

The shoot length data is presented in Table 2. Revealed that the maximum length (120.83 cm) of the root was recorded in T_1 (FYM 25 ton/ha), which was found to be significantly superior over other treatments, followed by 115.67 cm in T_2 (FYM 20 ton/ha) and 108.37 cm in T_3 (FYM 15 ton/ha). The minimum shoot length (78.46 cm) was found in the T_7 control. The maximum length of shoot (102.70 cm) was recorded in T_1 (FYM 25 t/ha). Minimum shoot length (90.87 cm) found in T_7 control. The application of FYM at the rate of (10 t/ha) was found to increase shoot length in Albizzia chinensis. Guleria (2006) [4].

3.2.2 Root length (cm)

The root length data is presented in Table 2. Revealed that the maximum length (17.50cm) of the root was recorded in T_1 (FYM 25ton/ha), which was found to be significantly superior over other treatments, followed by 16.56cm in T_2 (FYM 20ton/ha) and 15.20cm in T_4 (vermicompost 8ton/ha). The treatment T_7 (control) observed a minimum (11.56cm) root length. The maximum root length at 120 days after sowing (17.56 cm) was recorded in T_1 (FYM 25 ton/ha) and the minimum root (11.56) was recorded in T_7 control. The application of FYM at the rate of (10 tons/ha) was found to Increase root length, in Albizia Chinensis. Guleria (2006) [4].

3.2.3 Number of primary branches per plant

The data clearly showed that there was a significant difference in the number of Primary branches per plant belonging to different treatments as presented in Table 2. The maximum (9.70) number of primary branches per plant was recorded in T_4 (Vermicompost 9ton/ha), followed by 9.30 in T_1 (FYM 25ton/ha) and 9.03 in T_5 (vermicompost 7 ton/ha), while the

minimum number (6.6) of primary branches per plant was found in T_7 (control). The maximum number of primary branches per plant (9.70 at 120 DAS) was recorded in T_1 (FYM 25ton/ha), while the minimum number of primary branches per plant (6.6) was found in T_7 (control). Mohamed *et al*. (2004) [12].

3.2.4 Number of secondary branches per plant

Significant variations were observed among all the treatments for the number of Secondary branches per plant as presented in Table 2. The maximum (14.06 cm) number of secondary branches per plant was recorded in T_4 (vermicompost 9t/ha), followed by 12.56cm in T_5 (vermicompost 7 tone/ha) and 12.43 in T_1 (FYM 25ton/ha), while the lowest (10.06) number of secondary branches per plant was found in T_7 (control). The maximum number of secondary branches per plant (14.06 at120 DAS) was recorded in T_4 (Vermicompost 9ton/ha), while the lowest number of secondary branches per plant (10.6) was found In T_7 (control). Moghadam *et al*. (2009) [22] reported a significant effect of vermicompost on the percentage of Sweet Fennel branches. Godara *et al*. (2014) [3]. That organic fertilizers increased the Number of main and lateral branches.

3.2.5 Fresh weight (g)

This is apparent from the data presented in Table 2. The maximum (97.60 g) fresh weight was recorded in T_1 (FYM 25 ton/ha), which was found to be significantly superior to other treatments, Followed by 82.56.g in T_2 (FYM 20 ton/ha) and 70.86 g in T_3 (FYM 15 ton/ha). The minimum (37.26g) Fresh weight was recorded in T_7 (control). The maximum dry weight (37.13g) was recorded in T_1 (FYM 25 t/ha) and the minimum dry weight (20.70) was recorded in T_7 (control). Similar results were found in Meena *et al*. (2020) [11].

3.2.6 Dry weight (g)

This is apparent from the data presented in Table 2. The maximum (37.13g) dry weight was recorded in T_1 (FYM 25 ton/ha), which was found to be significantly superior to other treatments, followed by 30.73 g in T_2 (FYM 20ton/ha), And 28.23 g in T_4 (vermicompost 9ton/ha). The minimum (20.70g) dry weight was recorded in T_7 (control). The maximum dry weight (37.13g) was recorded in T_1 (FYM 25 t/ ha) and the minimum dry weight (21.70g) was recorded in T_7 (control). Malhotra, and Vashishtha (2008) [10] conducted a field experiment during the winter seasons of 1992-93 and 1993-94 on nitrogen-deficient loamy sand soil of Anand (Gujarat) with three levels of FYM *viz*., 0, 10 and 20t ha^{-1} in mustard. Based on two-year results, they reported that dry matter accumulation per plant was significantly increased with successive levels of FYM from 0 to 20t ha^{-1}.

3.3 Yield Attributes

3.3.1 Number of umbels per plant

The data related to the no of umbels per plant is presented in Table 3. Clearly showed that there was a significant difference in the number of umbels per plant among the different treatments. Among all treatments, T_4 (vermicompost 9q/ha) showed a maximum (13.50) umbels/plant in fennel followed by T_5 (Vermicompost 7ton/ha) (13.33) and T_6 (vermicompost 5ton/ha) 11.83, whereas, the minimum (9.83) found in T_7 (control).

3.3.2 Number of Umbellets per Umbel

The data related to the no of umbellets per umbel is presented in Table 3. Among all treatments, T_4 (vermicompost 9q/ha) showed a maximum (20.89) umbellets/umbel in fennel followed by T_5 (Vermicompost 7 ton/ha) (20.75) and T_6 (vermicompost 5ton/ha) 18.87, whereas, the minimum (15.88) found in T_7 (control).

3.3.2 Test weight (g)

A detailed review of the data is shown in Table 3. Indicates that the test weight was significantly influenced by the treatments. The maximum test weight (7.16 g/1000 seeds) was recorded in T_4 (vermicompost 9 ton/ha), which was found to be significantly higher than other treatments, followed by 7.16 g/1000 seeds) in T_5 (vermicompost 7 ton/ha) and 6.60 in T_3 (FYM 15 ton/ha). The minimum (6.0 g / 1000 seeds) was found in T_7 (control).

3.3.3 Yield per plant (g)

The data is presented in Table 3. Show that the yield per plant was significantly influenced by different treatments. The maximum yield (7.66 g) per plant was recorded in T_4 (vermicompost 9 ton/ha), followed by (7.40 g) in T_1 (FYM 25 ton/ha) and (7.30 g) in T_5 (vermicompost 7 ton/ha), whereas Minimum (5.73 g) yield per plant was found in T_7 (control).

3.3.4 Yield per plot (g)

The data is presented in Table 3. Show that the yield per plot was significantly influenced by different treatments. The maximum yield (278 g) per plot was recorded in T_4 (vermicompost 9 ton/ha), followed by 252 g in T_1 (FYM 25 ton/ha) and 250.33 g in T_5 (vermicompost 7 ton/ha), whereas the minimum (190.66 g) yield per plot was found in T_7 (control).

3.3.5 Yield per hectare (Q/ha.)

The data is presented in Table 3. The maximum yield (12.87 q/ha) was recorded in T_4 (Vermicompost 9 ton/ha), followed by 11.66 q/ha in T_1 (FYM 25ton/ha) and 11.57 q/ha in T_5 (Vermicompost 7 ton/ha) whereas minimum yield (8.82q/ha) was found in T_7 (control).

Table 1: Effect of different doses of Organic manures FYM and vermicompost on Plant and Root length, No. of primary and secondary branches per plant and Fresh weight and Dry weight of fennel at 90 DAS

Treatment	Plant length (cm)	Root length (cm)	No. of primary	No. of secondary	Fresh Weight (g)	Dry Weight (g)
T_1	16.87	5.47	9.13	12.40	199.13	21.53
T_2	16.00	5.17	7.53	11.27	139.57	14.53
T_3	14.23	4.50	8.00	11.63	141.33	15.40
T_4	13.10	5.73	8.13	13.07	150.13	13.93
T_5	10.83	4.23	6.80	11.13	103.40	10.13
T_6	10.80	4.03	7.60	10.67	99.27	10.23
T_7	11.03	3.47	6.53	9.40	75.73	6.53
C.D.	4.20	1.43	1.53	1.64	56.02	4.31
SE (m) ±	1.35	0.46	0.49	0.53	17.98	1.38

Table 2: Effect of different doses of organic manures FYM and vermicompost on Plant height, Root length, No. of primary and secondary branches, fresh weight and dry weight of fennel at 120 at DAS

Treatments	Plant height	Root length	No. of primary branches.	No. of Secondary branches.	Fresh weight (g)	Dry weight (g)
T_1	120.83	17.57	9.30	12.43	90.93	37.13
T_2	115.67	16.50	7.80	11.47	82.57	30.73
T_3	108.37	14.87	8.03	11.60	70.87	27.53
T_4	103.30	15.20	9.70	14.07	53.60	28.23
T_5	95.50	14.43	9.07	12.57	53.15	24.93
T_6	93.13	14.13	8.83	11.00	50.50	25.01
T_7	90.87	11.57	6.67	10.07	37.27	21.70
C.D.	8.09	1.78	1.53	1.90	14.18	4.70
SE (m) ±	2.60	0.57	0.49	0.61	4.55	1.51

Table 3: Effect of different doses of Organic manures (FYM and vermicompost) on Umbels per plant and Umbellets per Umbel at 120 DAS, Test weight (g), Yield per plant (g), Yield per plot (g). And yield per hectare (Q)

Treatment	Umbels per plant (120 DAS)	Umbellets per Umbel (120 DAS)	Test weight (g)	Yield per plant (g)	Yield per plot (g)	Yield per hectare (Q.)
T_1	11.17	18.23	6.73	7.40	252.67	11.66
T_2	11.50	18.90	6.83	6.87	250.00	11.57
T_3	10.17	18.53	6.97	6.53	223.67	10.35
T_4	13.50	20.89	7.53	7.67	278.00	12.87
T_5	13.33	20.75	7.20	7.30	250.33	11.57
T_6	11.83	18.87	7.17	6.73	248.00	11.48
T_7	9.83	15.88	6.00	5.73	190.67	8.82
C.D.	2.14	2.61	N/A	1.08	26.72	2.08
SE (m) ±	0.69	0.84	0.31	0.35	8.58	0.63

4. Conclusion

This study comprehensively analyzed the growth and yield parameters of Foeniculum vulgare (fennel) under various organic fertilizer treatments. The results revealed significant differences in plant height, root length, number of primary and secondary branches, as well as fresh and dry weights among the treatments. Notably, the treatment with FYM at 25 tons/ha (T_1) consistently demonstrated superior growth characteristics compared to other treatments, including vermicompost and the control. These findings underline the positive impact of organic fertilizers on fennel growth. But the maximum secondary branches (14.07) seed yield (12.87 q/ha) was recorded in T_4 (Vermicompost 9 ton/ha) at garhwal valley condition, it means Vermicompost well contributes for secondary growth and seed yield in fennel. Such research contributes valuable insights into optimizing agricultural practices and enhancing crop productivity, particularly for medicinal and aromatic plants like fennel.

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