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Consequence of organic manure and biofertilizers on growth, yield and economics of dill (*Anethum graveolens* L.)

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Abstract
A field experiment of winter season was conducted during the year of 2020-21 to study the result of organic manure and biofertilizers on growth and yield of dill (*Anethum graveolens* L.). The eight treatment combinations of FYM, vermicompost and biofertilizers were tested in randomized block design and replicated three times. Organic manure and Biofertilizers significantly influenced growth and yield of dill. Significantly biological yield and grain yield with harvest index were observed under treatment FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha). Findings suggested that application of biological fertilizers significantly increased grains performance, biological yield per plant, plant height, fresh weight, dry weight, umbels number per plant, number of grains per umbel. Result revealed that, significant maximum plant height (9.08, 70.49, and 150 cm), fresh weight (2.74, 147.13, 469.40 g plant^{-1}) and dry weight (0.41, 7.54, 85.87 g plant^{-1}) were verified with treatment T_7 on forty, eighty and one twenty days after sowing, correspondingly. Though, sooner germination (7.8 days), flowering (82.67 days), maturity (154.40 days), and higher umbels number (121.07 plant^{-1}), umbellets number (35.47), number of grains per umbel (642.10), grain yield (19.69 q ha^{-1}), biological yield (42.67 q ha^{-1}), harvest index (46.14%) and benefit cost ratio (2.34) were recorded with treatment T_7 while, they were lowest with untreated control.

Keywords: *Anethum graveolens*, organic manure, biofertilizers, growth and yield

1. Introduction
Dill (*Anethum graveolens* L.), readily acknowledged as sowa, is one of the oldest cultivated grain spices of India. It is a biennial or annual herb of the Apiaceae or Umbelliferae family. It grows up to 90-120 cm tall and has slender branched stems, finely divided leaves, and small umbels of yellow flowers. Younger tender leaves are most important part for culinary use and grains as spice. The leaves could be used as food, salads, sea foods, and soups. The grains could be used in soups, bread and flavoring pickles. Dill grain have pleasant aroma with warming flavors is excellent for flavoring and seasoning. The grain used as an anti-spasmodic, anti-flatulent, carminative, anti-inflammatory, anti-rheumatic and diuretic in pharmacological industry and reduce the level of cholesterolemia (Lanky *et al*. 1993) [1]. Dill leaves have excellent antioxidant activities (Singh *et al*. 2005) [2].

Solicitation of organic manure with biofertilizers such as vermicompost and nitrogen preservative bacteria has led to diminish in the use of chemical fertilizers and has provided good value products free of injurious agrochemicals (Moradi *et al*., 2010; Thomash *et al*., 2020a) [3, 4]. Biological Fertilizers application has controlled to a decrease in the use of mineral fertilizers and has provided top quality products free of harmful agrochemicals for safety of social and have useful impact on soil physical and chemical assets and provide plants with a good and save source of nutrients (Darzi, 2012; Chundawat *et al*., 2023) [5, 6]. Use of organic and chemical fertilizers could improve soil physical properties by changing the organic carbon content of the soil and the chemical composition of the soil solution, which rises the plant's ability to increase the plant's access to high-consumption elements (Chundawat *et al*., 2017; Patidar *et al*., 2019) [7, 8].

Bid of biofertilizers provides effective application of biological appliance of plant nutrition and growth promotion. The biofertilizers rally the sustainability of the soil and make it extra productive. Biofertilizer boosts the efficiency of the soil either by fixing atmospheric nitrogen or exciting plant growth through synthesis of growth helping substances (Kumar *et al*., 2023)

[9]. Therefore, cautious and suitable use of organic and inorganic source is too much crucial not only for gaining higher profit and quality produce but also to preserve soil health and sustainability for extensive era (Patil *et al*., 2016) [10]. More the use of organic sources like biofertilizer, FYM and green manure has its particular importance as it let down the cost of production keeps soil health and is effortlessly accessible to the minor and marginal growers.

2. Materials and Methods

The field experiment was accompanied during winter season of 2020-21 at the Horticulture (Farm) Horticulture College, Mandsaur-458001, Rajmata Vijayaraje Scindia Agriculture University, Gwalior, Madhya Pradesh, India. The trial soil is medium black clay loamy soil having pH 7.7, EC 0.64 ds/m, available nitrogen 227 kg ha^{-1}, available phosphorus 15.5 kg ha^{-1} and available potassium 403 kg ha^{-1}. The experiment was design in randomized block design with three time repetitions. There were eight treatments in the experiment *viz*., T_1- Absolute control, T_2- FYM (10 ton/ha), T_3- Vermicompost (2.5 ton/ha), T_4- *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_5 - FYM (10 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_6 - Vermicompost (2.5 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_7 - FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha), T_8 - FYM (5 ton/ha) + Vermicompost (1.25 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha). The Dill cv. NRCSS-AD-1 was taken for the experiment. All the traits were recorded on forty, eighty and one twenty days from sowing.

3. Results and Discussion

3.1 Growth attributes

Result confirmed from Table 1 that, significant maximum plant height (9.08, 70.49, and 150 cm), fresh weight (2.74, 147.13, 469.40 g $plant^{-1}$) and dry weight (0.41, 7.54, 85.87 g $plant^{-1}$) were recorded with treatment T_7 - FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) while, minimum plant height (6.26, 30.80, and 107 cm), fresh weight (1.37, 96.53, 207.13 g $plant^{-1}$) and dry weight (0.14, 5.91, 56.73 g $plant^{-1}$) at 40, 80 and 120 from sowing date, correspondingly. This may be due to positive effect of *Azotobacter* and Pseudo*m*onas which biologically fixed nitrogen and solubilization of soil phosphate, considerably affect plant growth regulators improve the plant performance. *Azotobacter* is able to produce antifungal compounds that fight plant diseases, as a result, improve the overall plant growth. Vermicompost also have high water-holding capacity and proper supply of macro and micro-nutrients has encouraging consequence on dry matter production and afterward enhanced plant weight. Conferring to the present analysis, biofertilizer enlarged plant tallness by increasing the nitrogen content and the proportion of photosynthesis. The present result was derived from the improvement of nitrogen fixing bacteria' activities which are in agreement with the previous studies carried out on fennel, turmeric and hyssop. The overhead outcomes are in close conformity with the judgements of Krishna *et al*. (2008) [11], Darzi *et al*. (2012) [5] and Chandravanshi *et al*. (2021) [12] in dill, fennel and turmeric.

3.2 Phenology of dill

In the present study, it was observed that application of organic manure and biofertilizers had significantly influenced the phenology of dill (Table 2). The investigation exposed that the sooner germination (7.8 days), flowering (82.67days) and maturity (154.40 days) were taken with T_7- FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) and late germination (10.60 days), flowering (93.27days) and maturity (163.87 days) untreated control conditions. This finding is due to the combination of biofertilizers and organic manures which improves germination indexes such as percentage and speed of germination, viability, and also the length of roots and stems of plants Krishna et.al. (2008) [11]. In addition to nitrogen fixation, Azospirillum improves root growth through generation of stimulating compounds, and these results in an increase in water and nutrient uptake and the general performance of the plant Yadav *et al*. (2023) [13]. Moreover, vermicompost application improves the biological activities of soil and mineral element absorption caused more biomass production, flowering and umbel number per plant. These findings are in accordance with the observations of Darzi *et al*. (2012) [5] and Shakywa *et al*. (2022) [14].

3.3 Yield and yield contributing parameters

All yield attributes of dill were significantly enhanced with the application of different organic manures and biofertilizers as showed in Table 3. The investigation publicised that the maximum umbels number (121.07 $plant^{-1}$), umbellets number (35.47), number of grains per umbel (642.10), grain yield (19.69 q ha^{-1}), biological yield (42.67 q ha^{-1}) and harvest index (46.14%) were found with T_7- FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) while, the lowest umbels number(53.80 $plant^{-1}$), umbellets number (27.40), number of grains per umbel (542.07), grain yield (11.50 q ha^{-1}), biological yield (30.28 q ha^{-1}) and harvest index (37.97%) under control. This may due to the combined application of organic manures with biofertilizers. They increases the growth rate because of the water and mineral uptake such as; nitrogen and phosphorus, greater biological N fixation, higher synthesis of plant growth hormones and enhanced availability of P which leads to improved yield and yield attributes and biomass (Tank *et al*., 2022) [15]. The biofertilizers application promotes the vegetative growth of dill plant and this promotion was reflected in increasing the grainyield, they have the ability not only to fix nitrogen but also to release certain phytohormons which could stimulate plant growth, absorption of nutrients and photosynthesis process. These all the above plant functions and are responsible for the enhancement of grain yield earlier reported by Garwal *et al*. (2023) [16]. These findings are in agreement with the findings of Thomas *et al*. (2020b) [17].

3.4 Economics of the treatments

The combination of organic manures and biofertilizers in dill had enhanced financial side of applied treatments (Table 4). However, treatment T_7- FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) gave the high gross return, net return and Benefit: Cost ratio in the present experiment. Alike, outcomes were found by the Chouhan *et al*. (2023) [18].

Table 1: Outcome of organic manures and biofertilizers on morphology of and biomass of dill

Treatments	Plant height (cm)			Fresh weight (g)			Dry weight (g)		
	40 D.A.S.	80 D.A.S.	120 D.A.S.	40 D.A.S.	80 D.A.S.	120 D.A.S.	40 D.A.S.	80 D.A.S.	120 D.A.S.
T_1	6.26	30.8	107	1.37	96.53	207.13	0.14	5.91	56.73
T_2	6.73	42.4	123.27	1.43	117.07	270.73	0.23	6.20	75.44
T_3	7.48	46.47	123.13	1.45	117.87	340.80	0.24	6.27	78.05
T_4	7.55	48.17	128.47	1.49	126.13	352.73	0.27	6.30	81.33
T_5	7.8	52.32	132.4	1.65	152.40	402.60	0.34	7.14	82.53
T_6	7.87	48.34	129.13	1.40	141.13	358.20	0.33	6.50	81.32
T_7	9.08	70.49	150	2.74	147.13	469.40	0.41	7.54	85.87
T_8	8.13	54.63	146.87	1.66	149.13	432.93	0.35	7.20	83.54
S.Em(±)	0.17	1.05	3.32	0.06	3.64	13.00	0.01	0.17	1.68
CD (5%)	0.52	3.18	10.07	0.17	11.05	39.43	0.02	0.50	5.09

T_1 - Absolute control, T_2- FYM (10 ton/ha), T_3 - Vermicompost (2.5 ton/ha), T_4 - *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_5 - FYM (10 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_6 - Vermicompost (2.5 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_7 - FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) and T_8 - FYM (5 ton/ha) + Vermicompost (1.25 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha)

Table 2: Outcome of organic manures and biofertilizers on phenology of dill

Treatments	Days to 50% germination	Days to 50%flowering	Days to Maturity
T_1	10.60	93.27	163.87
T_2	9.00	85.47	162.67
T_3	9.20	85.33	161.07
T_4	9.13	85.07	161.13
T_5	8.67	83.93	159.60
T_6	9.13	84.87	161.00
T_7	7.80	82.67	154.40
T_8	8.33	83.80	157.90
S.Em(±)	0.20	0.91	0.76
CD (5%)	0.61	2.75	2.29

T_1 - Absolute control, T_2- FYM (10 ton/ha), T_3 - Vermicompost (2.5 ton/ha), T_4 - *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_5 - FYM (10 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_6 - Vermicompost (2.5 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_7 - FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) and T_8 - FYM (5 ton/ha) + Vermicompost (1.25 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha)

Table 3: Outcome of organic manures and biofertilizers on yield and their components of dill

Treatments	No of umbel per plant	No of umbellets per umbel	No of grain per umbel	Grain yield (q ha-1)	Biological yield (q ha-1)	Harvest index (%)
T_1	53.80	27.40	542.07	11.50	30.28	37.97
T_2	98.93	30.93	576.17	13.69	39.19	34.93
T_3	104.27	30.67	614.33	15.19	39.77	38.19
T_4	100.73	30.60	630.07	16.42	39.82	41.23
T_5	111.00	31.80	637.00	17.94	41.69	43.03
T_6	101.80	30.73	639.37	17.18	40.17	42.76
T_7	121.07	35.47	643.20	19.64	42.67	46.14
T_8	112.60	32.80	642.01	18.26	41.78	46.09
S.Em (±)	2.69	0.70	6.74	0.39	0.09	0.84
CD (5%)	8.16	2.13	20.45	1.17	0.30	2.54

T_1 - Absolute control, T_2- FYM (10 ton/ha), T_3 - Vermicompost (2.5 ton/ha), T_4 - *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_5 - FYM (10 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_6 - Vermicompost (2.5 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_7 - FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) and T_8 - FYM (5 ton/ha) + Vermicompost (1.25 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha)

Table 4: Outcome of organic manures and biofertilizers on financial side of the treatments of dill

Treatments	Gross profit (₹ ha^{-1})	Net profit (₹ ha^{-1})	B: C Proportion (₹ ha^{-1})
T_1	57500.00	38400.00	1.05
T_2	68450.00	42350.00	1.62
T_3	75950.00	51850.00	2.15
T_4	82100.00	57200.00	2.29
T_5	89700.00	60800.00	2.10
T_6	85900.00	59000.00	2.19
T_7	98200.00	68800.00	2.34
T_8	91300.00	63400.00	2.27

T_1 - Absolute control, T_2- FYM (10 ton/ha), T_3 - Vermicompost (2.5 ton/ha), T_4 - *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_5 - FYM (10 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_6 - Vermicompost (2.5 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha), T_7 - FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) and T_8 - FYM (5 ton/ha) + Vermicompost (1.25 ton/ha) + *Azotobacter* (3 kg/ha) + PSB (5 kg/ha)

4. Conclusions

On the basis of research and the results stated, it could be concluded that, the diverse levels of organic manure and biofertilizers significantly influenced the growth, yield features and benefit cost ratio of Dill. Hence, out of eight treatments, the growth and yield attributes likely of dill be improved with the use of FYM (5 ton/ha) + Vermicompost (2 ton/ha) + *Azotobacter* (3 kg /ha) + PSB (5 kg/ha) (T_7).

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6. Declaration of Conflicting Interests

No possible conflicts of attentiveness with the present research.

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