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Effect of Different Organic Manures on Growth Performance, Yield and Economics of Kharif Maize (*Zea mays* L.) on Eastern Plain Zone of Uttar Pradesh of Prayagraj Region

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The present field experiment has conducted during the autumn season of 2019-20 at the crop research farm of Department of Soil Science & Agriculture Chemistry, SHUATS, Prayagraj, (UP). The aim of study to evaluate the effect of different organic manures on growth parameters, yield, yield component and economics of autumn Maize (*Zea mays* L.). The experiment consisted of 9 treatments in randomized block design with three replications consisted of T_1: FYM @ 5 t ha^{-1}, T_2: FYM @ 10 t ha^{-1}, T_3: FYM @ 15 t ha-1, T_4: VC @ 5 t ha^{-1},T_5: VC @ 10 t ha^{-1}, T_6: VC @ 15 t ha^{-1}, T_7: BK @ 5 t ha^{-1},T_8: BK @ 10 t ha^{-1}, T_9: BK @ 15 t ha^{-1}. On the basis of the results emanated from present investigation, it could be concluded that application of vermicompost @ 15 tonnes ha^{-1} shows higher values in terms of growth parameter i.e. plant height (261.63 cm at 90 DAS), dry matter accumulation (177.56 g), cob length (20.82 cm) and cob girth (17.39 cm) and yield

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component i.e. number of filled cob plant^{-1} (2.33), number of grains cob^{-1} (442.88), number of grain row cob^{-1} (36.99), average cob weight (261.55 g) and test weight (220.53 g). Results also showed that application of vermicompost @ 15 tonnes ha^{-1} significantly enhanced productivity parameter i.e. Grain yield (3544.33 kg ha^{-1}), green fodder yield (9810.67 kg ha^{-1}), biological yield (13355 kg ha^{-1}) and harvest index (26.54 %) followed by Bokashi Manures @ 15 tonnes ha^{-1}. Higher values of economics *viz*., gross return (₹ 167915.9 ha^{-1}), net return (₹ 333875.9 ha^{-1}) and B:C ratio in maize was observed with the application of vermicompost @15 tonnes ha^{-1} except cost of cultivation.

Keywords: Bokashi manure; Cob; economics and vermicompost.

1. INTRODUCTION

Maize (*Zea mays* L) is one of the most versatile emerging crops having wider adaptability under varied agro-climatic conditions. In India, maize is the third most important food crops after rice and wheat [1]. Corn is farmed over more than 175 million hectares (mha) in 166 countries, with a total yield of roughly 1068.30 million tonnes. The United States, China, Brazil, India, Mexico, and Argentina are the top six corn-producing countries. India produces around 2.48 percent of the world's grain (26.50 million tonnes) [2].

The composition of maize is carbohydrate (71.88%), protein (8.84%), fat (4.57%), fiber (2.15%) and ash (2.33%). It also contains vitamin C, vitamin E, vitamin K, vitamin B_1 (thiamine), vitamin B_2 (niacin), vitamin B_3 (riboflavin), vitamin B_5 (pantothenic acid), vitamin B_6 (pyridoxine), folic acid, selenium, N-p-coumaryl tryptamine, and N-ferrulyl tryptamine. Potassium is a major nutrient present, which has a good significance because an average human diet is deficient in it [3]. Maize germ contains about 45–50% of the oil that is used in cooking salads [4]. The oil contains 14% saturated fatty acids, 30% monounsaturated fatty acids, and 56% polyunsaturated fatty acids. The refined maize oil contains linoleic acid 54–60%, oleic acid 25–31%, palmitic acid 11–13%, stearic acid 2–3% and linolenic acid 1% [5].

Organic fertilizer emerged as a feasible option to concerns related to increasing food contamination. Organic matter in general helps to regulate the biological, chemical and physical properties of the soil by acting as a “revolving nutrient fund”; and as an agent to improve soil structure, maintain tilth and minimize erosion. The accumulated organic manure is a storehouse of plant nutrients. The stable organic fraction (humus) adsorbs and holds nutrients in plant available- form. Organic matter releases nutrients in available form to plants upon decomposition [6].

Many organic materials contain other components which can contribute significantly to increase crop yields, including organic matter, secondary and micronutrients and sometimes lime. In some cases, the organic matter fraction of a particular material may be of greater value than its total nutrient content because of the beneficial effect of organic matter on soil physical properties and soil productivity [7-10]. Various workers have tried different types of organic manure to find out their effectiveness, efficiency and cost benefit impacts as compared to the inorganic fertilizers [11]. Among the organic manures which have been tried and used are Farmyard manure, Vermicompost and Bokashi manure. Farmyard manure is the oldest organic manure used by man ever since he involved in farming. It consists of litter, waste products of crops mixed with animal dung and urine. Therefore, it contains all the nutrient elements present in the plant itself, which are returned to the soil when it is applied to the field for the benefit of succeeding crop [12,13]. The preparation of farmyard manure offers one of the best manure for utilizing farm and other agricultural wastes and simultaneous enrichment of humus. Bokashi is a natural soil amendment that can be prepared using farm-based, locally derived materials such as rice/maize bran. It focuses on the preparation of organic soil and plant amendments using microbiological processes [14]. Practical advantages associated with the use of Bokashi manure include the shortened preparation time (only 2- 4 weeks) relative to traditional compost (6 months) besides its low cost compared to commercial fertilizers because it is manufactured from low-cost, locally available materials [15].

Vermicomposting is a green technology that converts organic wastes into plant-available nutrient rich organic fertilizer. It has also been found to reduce heavy metal concentration in contaminated feeding materials. Vermicompost (VC), when used as fertilizer, not only bears a positive impact on soil quality, plant growth and yield but also enhances nutritional value of crops produced [16].

2. MATERIALS AND METHODS

2.1 Experimental Soil

The experimental field is sandy loam in texture, neutral in reaction (pH 6.76), medium inorganic carbon (0.55%), available N (282.92 kg ha^{-1}), medium in available P (18.67 kg ha^{-1}), and high in available K (132.15 kg ha^{-1}).

2.2 Study Design

The experiment was laid out in a randomized block design (RBD) assigning treatment combinations *viz.* T_1 [FYM @ 5 tonnes ha^{-1}], T_2 [FYM @ 10 tonnes ha^{-1}], T_3 [FYM @ 15 tonnes ha^{-1}], T_4 [VC @ 5 tonnes ha^{-1}], T_5 [VC @ 10 tonnes ha^{-1}], T_6 [VC @ 15 tonnes ha^{-1}], T_7 [BK @ 5 tonnes ha^{-1}], T_8 [BK @ 10 tonnes ha^{-1}], T_9 [BK @ 15 tonnes ha^{-1}], with three replications. Each treatment was randomly allocated within them. The row-to-row and seed to seed distance were 60 and 20 cm, respectively.

2.3 Preparation of Vermicompost

Vermicompost was prepared from different substrate materials which was locally available (from farmers field and research station) such as wheat straw, maize stock, sorghum, chickpea. A red worm (*Eisenia foetida*) was used as a decomposer. The collected substrates were chopped and added to the worm bin. Animal manure was added to all substrates in equal amount. Substrates of 3kg kg mixed with 2kg of animal manure were filled based on the volume of worm bin/plastic bag. After moisture optimized 180 earthworms was counted and added to every treatment. Bottom face of plastic bag was drilled to avoid water logging. Water was sprayed, as it needed to keep the optimum moisture status of the worm feed.

2.4 Preparation of Bokashi Manure

EM-Bokashi was prepared from domestic wastes, wastes from market places like fruits especially banana and round potato and grass weeds from the farm, and EM-A in a 20L plastic bucket. Domestic wastes and weeds were collected and put into a bucket, then 100mls of EM-A was mixed with 1L of water and added in a bucket. Then, the bucket was closed tightly and left to decompose in a storage area for EM and after 10days EM-Bokashi was ready for application in the field [17].

2.5 Nutrient Composition of Manures

Organic Source	% N	% P	% K
Farm Yard Manure (FYM)	0.55 %	0.28 %	0.52 %
Vermicompost (VC)	1.5% - 2.2%	1.8% - 2.2%	1.0% - 1.5%
Bokashi Manure (BK)	1.22%	0.65%	2.04%

2.6 Manure Application

Three organic manures Bokashi, farmyard and vermicompost were applied in the soil 3 weeks before sowing each at the rate of 5 t ha^{-1}, 10 t ha^{-1} and 15 t ha^{-1}. They were thoroughly mixed in soil during the application.

2.7 Harvest Index

The harvest index was worked out with the help of following formula:

Harvest index (%) = Grain yield (kg ha^{-1})/ Biological yield (kg ha^{-1}) × 100

Net Profit (ha^{-1})

The net profit from each treatment was calculated separately by using the formula given below.

Net profit (ha^{-1}) = Gross return - Cost of cultivation

Cost Benefit Ratio (C: B)

The benefit ratio for each treatment was calculated by using following formula.

Cost Benefit Ratio = $\frac{\textbf{Cost of Cultivation}}{\textbf{Gross Return}}$

2.8 Statistical Analysis

The data recorded during the course of the investigation were subjected to statistical analysis by "Analysis of variance technique". The significant and non-significant treatment effects were judged with the help of 'F' (variance ratio) table. The significant differences between the means were tested against the critical difference at 5% probability level [18].

3. RESULTS AND DISCUSSION

3.1 Growth Characters

The data revealed that maximum plant height 70.31 cm at 30 DAS, 133.85 cm at 60 DAS and 216.63 cm at 90 DAS, dry matter accumulation (177.56 g plant^{-1}), cob length (20.82 cm) and cob girth (17.39 cm) was found with the application of T_6 [VC @ 15 tonnes ha^{-1}] followed by T_5 [VC @ 10 tonnes ha^{-1}], T_9 [BK @ 15 tonnes ha^{-1}] and T_3 [FYM @ 15 tonnes ha^{-1}]. The minimum plant height 62.49 cm at 30 DAS, 127.47 cm at 60 DAS and 179.90 cm at 90 DAS, dry matter accumulation (153.0 g plant^{-1}), cob length (17.35 cm) and cob girth (14.18 cm) was found with the application of T_1 [FYM @ 5 tonnes ha^{-1}] The results of the present investigation are also in agreement with the findings of Khan et al., [19], Asghar et al., [20] and Olusegun [21].

3.2 Yield Components

A cursory glance of data revealed that that maximum number of filled cob plant^{-1} (2.33), number of grains cob^{-1} (409.38), number of grain row cob^{-1} (36.99), average cob weight (261.55 g) and test weight (220.53 g) was found with the application of T_6 [VC @ 15 tonnes ha^{-1}] followed by T_5 [VC @ 10 tonnes ha^{-1}], T_9 [BK @ 15 tonnes ha^{-1}] and T_3 [FYM @ 15 tonnes ha^{-1}]. The minimum number of filled cob plant^{-1} (1.15), number of grains cob^{-1} (377.15), number of grain row cob^{-1} (31.22), average cob weight (192.22 g) and test weight (209.79 g) was found with the application of T_1 [FYM @ 5 tonnes ha^{-1}]. The results of present investigation are also in agreement with the findings of Ali et al., [22], Mahesh and Desai [23], Ponmozhi et al., [24] and Roopashree et al., [25].

3.3 Productivity Parameters

The data revealed that maximum productivity parameter, i.e. Grain yield (3544.33 kg ha^{-1}), green fodder yield (9810.67 kg ha^{-1}), biological yield (13355 kg ha^{-1}) and harvest index (26.54%) was found with the application of T_6 [VC @ 15 tonnes ha^{-1}] followed by T_5 [VC @ 10 tonnes ha^{-1}], T_9 [BK @ 15 tonnes ha^{-1}] and T_3 [FYM @ 15 tonnes ha^{-1}]. The minimum Grain yield (2773.67 kg ha^{-1}), green fodder yield (8181.00 kg ha^{-1}), biological yield (10954.67 kg ha^{-1}) and harvest index (25.32%) was found with the application of T_1 [FYM @ 5 tonnes ha^{-1}]. The results of present investigation are also in agreement with the findings of Muktamar et al., [26], Saleem et al., [15] and Kandil et al., [27].

Table 1. Effect of different organic sources of nutrients on growth parameters of Maize

Treatments	Plant height (cm)			Dry Matter Accumulation (g plant^{-1})	Cob Length (cm)	Cob girth (cm)
	30 DAS	60 DAS	90 DAS			
T_1	62.49	127.47	179.90	153.00	17.35	14.18
T_2	66.58	132.24	181.80	159.10	17.45	15.40
T_3	68.53	135.79	186.03	168.19	17.50	15.59
T_4	63.28	129.54	206.53	175.22	19.13	16.94
T_5	69.54	132.34	210.85	173.22	20.44	16.67
T_6	70.31	133.85	216.63	177.56	20.82	17.39
T_7	60.18	126.64	197.68	160.76	17.52	16.35
T_8	62.18	129.61	199.19	157.53	18.27	16.42
T_9	64.81	131.91	199.20	160.76	18.57	15.93
F-Test	S	S	S	S	S	S
C.D.(P=0.05)	0.848	1.73	2.788	4.535	0.342	0.850
S.Ed (+)	0.400	0.816	1.315	2.139	0.161	0.401

Where, T_1 - FYM @ 5 t ha^{-1}, T_2 - FYM @ 10 t ha^{-1}, T_3 - FYM @ 15 t ha^{-1}, T_4 - VC @ 5 t ha^{-1}, T_5 - VC @ 10 t ha^{-1}, T_6 - VC @ 15 t ha^{-1}, T_7 - BK @ 5 t ha^{-1}, T_8 - BK @ 10 t ha^{-1}, T_9 - BK @ 15 t ha^{-1} and C.D. – Critical Difference , S.Ed – Standard Error

Table 2. Effect of different organic sources of nutrients on yield components of Maize

Treatments	No. of Cob Plant^{-1}	No. of grain cob^{-1}	No. of grains row cob	Average cob weight (g)	Test weight (1000 grain)
T_1	1.15	377.15	31.22	192.22	209.79
T_2	1.41	383.85	30.49	196.42	214.56
T_3	2.18	385.77	34.58	201.78	214.22
T_4	1.70	403.27	32.68	237.56	216.59
T_5	2.00	408.25	34.93	228.66	214.17
T_6	2.33	409.38	36.99	261.55	220.53
T_7	2.11	422.88	34.89	208.57	216.32
T_8	1.41	412.22	35.73	207.58	215.64
T_9	2.22	418.86	36.52	255.80	216.27
F-Test	S	S	S	S	S
C.D.(P=0.05)	0.873	13.05	3.688	3.041	5.764
S.Ed (+)	0.415	6.156	1.740	1.435	2.719

Where, T_1 - FYM @ 5 t ha^{-1}, T_2 - FYM @ 10 t ha^{-1}, T_3 - FYM @ 15 t ha^{-1}, T_4 - VC @ 5 t ha^{-1}, T_5 - VC @ 10 t ha^{-1}, T_6 - VC @ 15 t ha^{-1}, T_7 - BK @ 5 t ha^{-1}, T_8 - BK @ 10 t ha^{-1}, T_9 - BK @ 15 t ha^{-1} and C.D. – Critical Difference , S.Ed – Standard Error

Table 3. Effect of different organic sources of nutrients on productivity parameters of Maize

Treatments	Grain yield (kg ha^{-1})	Green Fodder Yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
T_1	2773.67	8181.00	10954.67	25.32
T_2	2989.67	8513.33	11503	25.99
T_3	2948.33	8485.33	11433.66	25.79
T_4	3256.00	9119.33	12375.33	26.31
T_5	3272.33	9202.00	12474.33	26.23
T_6	3544.33	9810.67	13355.00	26.54
T_7	2973.33	8717.67	11691	25.43
T_8	3241.00	9088.33	12329.33	26.29
T_9	3241.67	9178.67	12420.34	26.10
F-Test	S	S	S	S
C.D.(P=0.05)	56.39	151.639	148.287	0.552
S.Ed (+)	26.60	71.53	69.950	0.260

Where, T_1 - FYM @ 5 t ha^{-1}, T_2 - FYM @ 10 t ha^{-1}, T_3 - FYM @ 15 t ha^{-1}, T_4 - VC @ 5 t ha^{-1}, T_5 - VC @ 10 t ha^{-1}, T_6 - VC @ 15 t ha^{-1}, T_7 - BK @ 5 t ha^{-1}, T_8 - BK @ 10 t ha^{-1}, T_9 - BK @ 15 t ha^{-1} and C.D. – Critical Difference , S.Ed – Standard Error

Table 4. Effect of different organic sources of nutrients on economics of Maize

Treatments No.	Gross return (₹)	Cost of cultivation (₹)	Net return (₹)	Cost benefit ratio
T_1	134929.8	70960	205889.8	1.90
T_2	143304.1	95960	239264.1	1.49
T_3	141950.6	120960	262910.6	1.17
T_4	155003.3	85960	240963.3	1.80
T_5	156039.2	125960	281999.2	1.24
T_6	167915.9	165960	333875.9	1.01
T_7	144276.9	70960	215236.9	2.03
T_8	154366.3	95960	250326.3	1.61
T_9	155017.5	120960	275977.5	1.28

Where, T_1 - FYM @ 5 t ha^{-1}, T_2 - FYM @ 10 t ha^{-1}, T_3 - FYM @ 15 t ha^{-1}, T_4 - VC @ 5 t ha^{-1}, T_5 - VC @ 10 t ha^{-1}, T_6 - VC @ 15 t ha^{-1}, T_7 - BK @ 5 t ha^{-1}, T_8 - BK @ 10 t ha^{-1}, T_9 - BK @ 15 t ha^{-1}

3.4 Economics

Maximum gross return (Rs. 167915.9 ha^{-1}), net return (Rs. 333875.9 ha^{-1}) was observed in treatment T_6 [VC @ 15 tonnes ha^{-1}] and the minimum gross return (Rs. 134929.8 ha^{-1}), net return (Rs. 205889.8 ha^{-1}) was observed in treatment T_1 [FYM @ 5 tonnes ha^{-1}]. Maximum benefit cost ratio (1:2.03 ratio) was observed in treatment T_7 [BK @ 5 tonnes ha^{-1}] and the minimum benefit cost ratio (1:1.01 ratio) was observed in treatment T_6 [VC @ 15 tonnes ha^{-1}]. Vermicomposting was the most economically viable manure treatment method due to low operating costs and higher returns on investment thus, can be recommended to farmers for production of a fertilizer that increases maize yields with assurance of economic returns. Similar finding were reported by Jjagwe et al., [28].

4. CONCLUSION

On the basis of above to find it is concluded that application of Vermicompost Manures (VC) @ 15 tonnes ha^{-1} gave the maximum growth, yield component and productivity parameter after crop harvest was found to be the best result of maize. So farmers should be suggested for better production and net profit in maize cultivation under organic farming by applying vermicompost @ 15 tonnes ha^{-1} so that soil health can also be sustained.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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