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Effect oforganic manures and methods of fertilizer application on growth component, yield parameters and nutrient uptake of maize hybrid COH(M)8 (*Zea mays* L.)

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Abstract

A field study was carried out was conductedto study the effect oforganic manures and methods of fertilizer application on growth components, yield parameters and nutrient uptake of maize hybrid COH(M)8 (*Zea mays* L.) at farmer'sfield of Kovakkulam village, Karur District during January- April 2021. The present investigation employed a randomized block design which consists of nine treatments and three replications. The treatments contain application of NPK fertilizers along with different organic manures *viz.,*FYM @ 12.5 t ha^{-1}, Vermicompost @5t ha^{-1} and Pressmud @ 5t ha^{-1}, were tested usingdifferentmethods of fertilizer application like soil application and drip fertigation. One treatment was keptascontrol (without fertilizer application). The results of the findings revealed that, the application of100% RDF through fertigation + Vermicompost 5 t ha^{-1} (T_7) recorded higher growth parameters during harvest *viz.,* plant height (180.05 cm), LAI (5.48), DMP (14685 kg ha^{-1}), leaf area duration at 60 DAS to harvest (122 days), CGR during60 DAS to harvest (15.61g m^{-2} day^{-1}), AGR during60 DAS to harvest (1.99cm $plant^{-1}$ day^{-1}), yield attributes *viz.,*number of grains row cob^{-1} (13.12), number of grains row^{-1} (23.82), total number of grains cob^{-1} (312.52), cob weight (83.59 g), test weight (24.19 g),grain yield (6193 kg ha^{-1}), stover yield (9769 kg ha^{-1}) and harvest index (38.80). Absorption rate of nitrogen (171.81 kg ha^{-1}), phosphorus (20.56 kg ha^{-1}) and potassium (151.26 kg ha^{-1}) also higher in this treatment. This treatment was onpar with application of100% RDF through fertigation + Pressmud @5 tha^{-1} (T_9) for all the growth and yield attributes. Lower growth parameters *i.e,*plant

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height (72.51 cm), LAI (3.56), DMP (6298 kg ha^{-1}), leaf area duration at 60 DAS to harvest (76 days), CGR during 60DAS to harvest (7.55 g m^{-2} day^{-1}) , AGRduring 60 DAS to harvest (0.57 cm $plant^{-1}$ day^{-1}), yield attributes *viz.,*number of grains row cob^{-1} (7.78), number of grains row^{-1} (14.71), total number of grains cob^{-1} (114.44), cob weight (30.72 g), test weight (24.05 g), grain yield (2270 kg ha^{-1}), stover yield (4250 kg ha^{-1}), harvest index (34.82) and nutrient uptake nitrogen (70.54 kg ha^{-1}), phosphorus (8.82 kg ha^{-1}), and potassium (64.87 kg ha^{-1}) weredocumented, control (T_1) treatment.

Key words : Soil application, fertigation, NPK, FYM, vermicompost, pressmud.

Maize (*Zea mays* L.), also known as the "queen of cereals" or "miracle crop," is cultivated in over and above 166 nations worldwide and is known for its importance in human and animal diets, higher yielding traits, short day length and C_4 type of photosynthesis, efficient use of solar energy, and extreme sensitivity to soil moisture excess and deficit.It is significant that the cereal crop, which accounts for 2% of India's overall agricultural output, is grown since it is used to make starch, oil, protein, and other industrial products as well as food and animal feed[10]. Maize was cultivated around 9,000 years earlier in Southern Mexico[7]. Maize plays major role in accountof 22 to 25 % world cereal area as well asin production[1]. It is grown on almost in 205 M ha with a global output of 1210 MTandyield of 5878 kg ha^{-1}, with a broader variety of soil, climate, biodiversity, and management approaches[5]. Maize supplies more than 20% of dietary calories in Asia when it is consumed as human food[12]. In 2021–2022, India produced 33.62 million tonnes on an area of 10.04 M ha, but the estimate for the kharif crop in 2022–2023 was 23.10 MT on 9.6 M ha of agricultural land[6]. It grows on 0.39 M ha across Tamil Nadu.

Two main natural resources required for effective agricultural cultivation are land and water. Prime agricultural lands are sadly disappearing as a result of climate change and competition from non-agricultural industries, which have an impact on crop yield and productivity. In addition, growing demands and a lack of suitable water have made farming more difficult[9]. With the goal of enhancing water and nutrient use efficiency, this has led people to search for alternative irrigation techniques such drip fertigation[15]. Nitrogen, phosphorus, and potassium are three macro-nutrients that are essential for photosynthesis besides various physiological functions in crops, including growth of shoots, roots, and flowers. They also facilitate effective water translocation and nutrition. Vermicompost, FYM, pressmud, and other organic manures have a key role in increasing agricultural yield and enhancing plant nutrient uptake. Vermicompost is more nutrient-dense and releases nutrients at a gradual rate that plants may easily absorb.

When applied to wheat in a wheat-maize cropping system, farmyard manure provided a long-lasting residual effect on maize and was more successful in restoring crop production in degraded soils. Pressmud application enhanced soil properties such rising levels of organic carbon, total nitrogen, and accessible phosphorus concentrations. The effect of pressmud on maize production and growth was examined. The crop production improved and the yield increased by 7 to 89% in comparison with the control crop. Theintegrating of organic and inorganic sources enhances soil biology, agricultural yield, water usage efficiency, and overall soil health[17].

A field investigation was done at farmer's landduring January – April, 2021 at Kovakkulam village, Karur district to study the effect of organic manures and methods of fertilizer application on growth components, yield parameters and nutrient uptake of maizehybrid COH(M)8 (*Zea mays* L.). The present study was designed by adopting a randomized block design which consists of nine treatments andthree replications.Crop spacing 60*20 cm was adopted.The treatments containapplication of 100 % RDF along with different organic manures *viz.,*FYM @ 12.5 t ha^{-1}, Vermicompost @ 5 t ha^{-1} and Pressmud @ 5 t ha^{-1}, were tested out various methods of application like soil application and fertigationand onetreatment kept as control. The location of the experiment field is located at10.96' North latitude, 78.08' East longitude with an altitude of 126 m above mean sea level. The soil type in the experimental field is sandy clay loam. The nutrient status of the experimental field soil was lower available nitrogen, medium available phosphorus and medium available potassium. The drip irrigation system is adapted in the experimental field for fertigation purpose. Fertigation was done every two days intervals in 3 different stages like Stage-I (6-25 DAS), Stage-II (26-60 DAS) and Stage-III (61-75 DAS). The fertilizer such as urea, DAP, and MOP areused to supply of NPKfor fertigation and fertilizer such as urea, SSP and MOP were used for soil application. The entire quantity of SSP applied as basal along with organic manures. Nitrogen and potassium were given splits into 10, 30 and 45 DAS. Other agronomical practices were carried out as per the recommendation. The yield and yield parameters were noted during harvesting stages of the crop.

Growth characters :

Application of different organic manures and methods of fertilizer application exerted significant influence on growth characters of maize (Table-1).

Plant height :

Among thedifferent organic manures andmethods of fertilizer application techniques, thetreatment withapplication of100% RDF through fertigation+vermicompost @ 5 t ha^{-1} (T_7) recordedhigherplant heightatharvest (180.05 cm). This treatment was comparable to the treatment with employing 100% RDF through fertigation + Pressmud @ 5 t ha^{-1} (T_9). This might have been due to the presence of an ideal microclimate for the plants and the provision of enough nutrients in a form that's readily available. This could have triggered the synthesis of growth regulators which include the auxins (IAA) and cytokinins, which has in

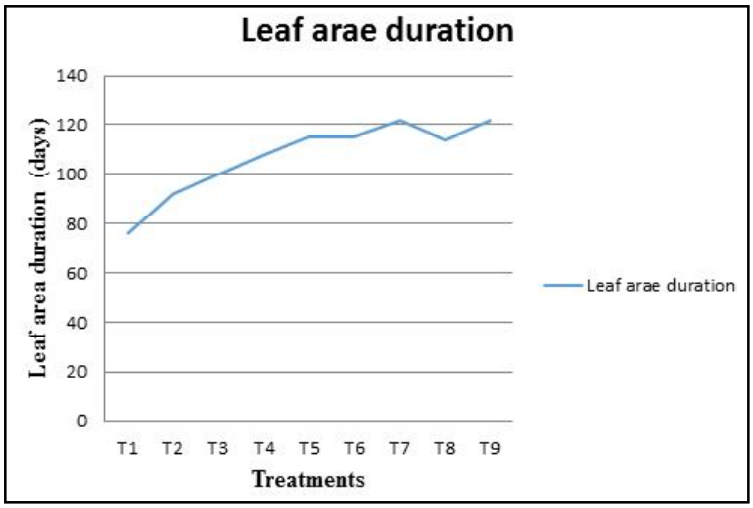

Fig. 1. Effect of organic manures and different methods of fertilizer application on leaf area duration (days)

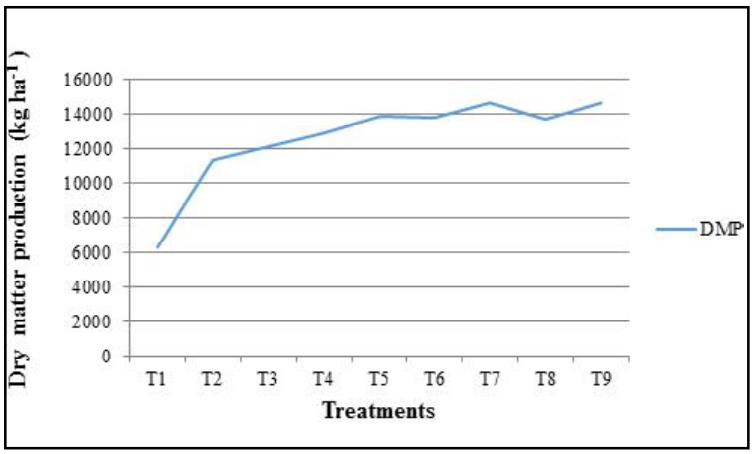

Fig. 2. Effect of organic manures and different methods of fertilizer application on crop dry matter production (kg ha^{-1})

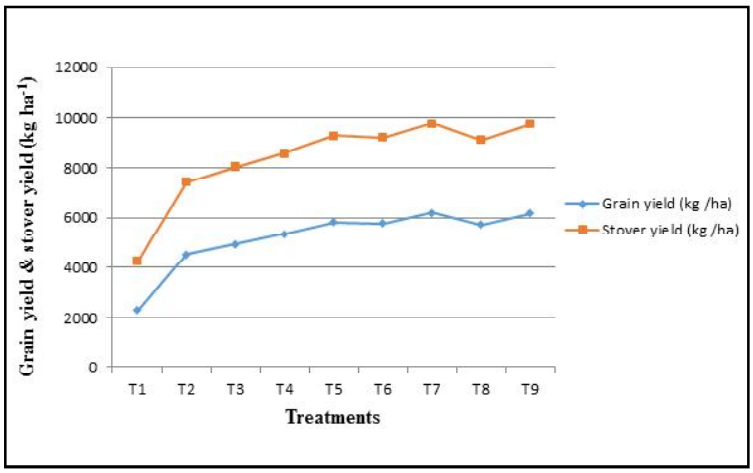

Fig. 3. Effect of organic manures and different methods of fertilizer application on Grain yield (kg ha^{-1}) and Stover yield (kg ha^{-1})

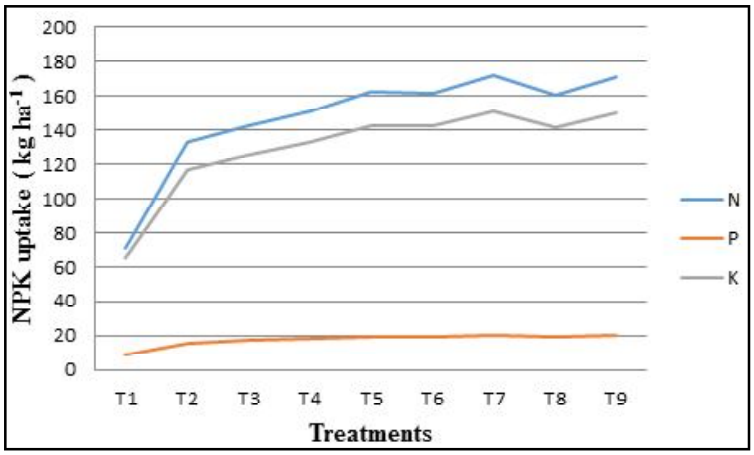

Fig. 4. Effect of organic manures and methods of fertilizer application on NPK uptake (kg ha^{-1}) by maize.

Table-1. Effect of organic manures and methods of fertilizer application on growth characters of maize at harvest stage

Treatment	Plant height (cm)	LAI (60 DAS)	LAD (days)	DMP (kg ha^{-1})	CGR (g m^{-2} day^{-1})	AGR (cm $plant^{-1}$ day^{-1})
T_1 – Control	52.54	3.56	76	6298	7.55	0.24
T_2 – 100% RDF through soil application @ 250:75:75 kg NPK ha^{-1}	110.87	4.39	92	11338	11.37	1.00
T_3 – 100% RDF through drip fertigation @ 150:75:75 kg NPK ha^{-1}	129.52	4.68	100	12146	12.39	1.28
T_4 – 100% RDF through soil application + FYM @ 12.5 t ha^{-1}	145.49	4.95	108	12934	13.38	1.50
T_5 – 100% RDF through drip fertigation + FYM @ 12.5 t ha^{-1}	165.37	5.23	115	13877	14.59	1.77
T_6 –100% RDF through soil application + Vermicompost @ 5 t ha^{-1}	163.04	5.22	115	13794	14.49	1.75
T_7 –100% RDF through drip fertigation + Vermicompost @ 5 t ha^{-1}	180.05	5.48	122	14685	15.61	1.99
T_8 – 100% RDF through soil application + Pressmud @ 5 t ha^{-1}	160.16	5.20	114	13701	14.37	1.72
T_9 – 100% RDF through drip fertigation + Pressmud @ 5 t ha^{-1}	178.49	5.47	122	14621	15.56	1.96
SEd	3.83	0.09	1.89	335.12	0.30	0.06
CD (p=0.05)	8.12	0.19	4.00	710.46	0.63	0.12

Table-2. Effect of organic manures and methods of fertilizer application on yield attributesof maize

Treatment	Number of grain rows cob^{-1}	Number of grains row^{-1}	Number of grains cob^{-1}	Cob weight (g)	Test weight (g)
T_1 – Control	7.78	14.71	114.44	30.72	24.05
T_2– 100% RDF through soil application @ 250:75:75 kg NPK ha^{-1}	11.40	21.80	248.52	65.39	24.06
T_3 –100% RDF through drip fertigation @ 150:75:75 kg NPK ha^{-1}	11.88	22.36	265.64	69.76	24.08
T_4 – 100% RDF through soil application + FYM @ 12.5 t ha^{-1}	12.29	22.84	280.70	74.00	24.12
T_5 – 100% RDF through drip fertigation + FYM @ 12.5 t ha^{-1}	12.71	23.33	296.52	78.94	24.16
T_6 –100% RDF through soil application + Vermicompost @ 5 t ha^{-1}	12.70	23.32	296.16	78.72	24.15
T_7 –100% RDF through drip fertigation + Vermicompost @ 5 t ha^{-1}	13.12	23.82	312.52	83.59	24.19
T_8 – 100% RDF through soil application + Pressmud @ 5 t ha^{-1}	12.68	23.30	295.44	78.22	24.14
T_9 – 100% RDF through drip fertigation + Pressmud @ 5 t ha^{-1}	13.09	23.79	311.41	83.09	24.18
SEd	0.10	0.20	6.40	0.12	0.11
CD (p=0.05)	0.28	0.39	13.54	3.83	NS

turn prompted cell division and elongation, raising plant height[12]. Lower plant height observed control (T_1) at harvest (72.51 cm).

Leaf area index (LAI) and Leaf area duration (LAD) :

Treatment with application of100% RDF through fertigation + vermicompost @ 5 t ha^{-1} (T_7) recorded higher leaf area indexat 60 DAS with the value of 5.48. The same treatment recorded higher leaf area duration of 122 days during 30 to60DAS (Fig. 1). This treatment was on par with treatment 100% RDF through fertigation + Pressmud @ 5 t ha^{-1} (T_9) regards to LAI and LAD.This could be due to result of sufficient amount of N being given through fertigation process during precisely timed intervals which may have triggered a greater activity of meristematic cells and their dividing, enzyme that regulates multiple metabolic processes, encouraged cell extension

Table-3. Effect of organic manures and methods of fertilizer application on grain yield, stover yield and harvest index of maize

Treatment	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Harvest index
T_1 – Control	2270	4250	34.82
T_2– 100% RDF through soil application @ 250:75:75 kg NPK ha^{-1}	4524	7434	37.83
T_3 – 100% RDF through drip fertigation @ 150:75:75 kg NPK ha^{-1}	4941	8034	38.08
T_4 – 100% RDF through soil application + FYM @ 12.5 t ha^{-1}	5324	8572	38.31
T_5 – 100% RDF through drip fertigation + FYM @ 12.5 t ha^{-1}	5823	9261	38.60
T_6 –100% RDF through soil application + Vermicompost @ 5 t ha^{-1}	5766	9184	38.57
T_7 –100% RDF through drip fertigation + Vermicompost @ 5 t ha^{-1}	6193	9769	38.80
T_8 – 100% RDF through soil application + Pressmud @ 5 t ha^{-1}	5701	9096	38.53
T_9 – 100% RDF through drip fertigation + Pressmud @ 5 t ha^{-1}	6175	9743	38.79
SEd	153.70	214.70	0.10
CD (p=0.05)	325.90	455.20	0.14

and production of proteins, and promoted pigment creation, boosting plant growth *i.e.,* height,leaves in comparison to the control. Higher photosynthesis rate, effective consumption of nutrients and execution, and greater root development leading to faster canopy formation could all contribute to improved crop output[3]. Lower LAI and LAD were recorded under control (T_1).

Dry matter production (DMP) :

Higher DMP was found under the treatment100% RDF through fertigation + vermicompost @ 5 t ha^{-1} (T_7) with 14685kg ha^{-1} at harvest (Fig. 2). This treatment was on par with the application of 100% RDF through fertigation + Pressmud @ 5 t ha^{-1} (T_9). This might be due toof vermicompost and press mud, which use both organic and inorganic resources, increase the presence of nutrients in soils. In addition to these, the organic manures also release substrate for beneficial soil microbes, growth hormones consisting of auxins, cytokinins, and gibberellic acids, enzymes, and vitamins, which are connected

Table-4. Effect of organic manures and methods of fertilizer application on NPK uptake (kg ha^{-1}) by maize

Treatments	N	P	K
T_1 – Control	70.54	8.82	64.87
T_2 – 100% RDF through soil application @ 250:75:75 kg NPK ha^{-1}	132.65	15.87	116.78
T_3 –100% RDF through drip fertigation @ 150:75:75 kg NPK ha^{-1}	142.11	17.00	125.10
T_4 – 100% RDF through soil application + FYM @ 12.5 t ha^{-1}	151.33	18.11	133.22
T_5 – 100% RDF through drip fertigation + FYM @ 12.5 t ha^{-1}	162.36	19.43	142.93
T_6 –100% RDF through soil application + Vermicompost @ 5 t ha^{-1}	161.39	19.31	142.08
T_7 –100% RDF through drip fertigation + Vermicompost @ 5 t ha^{-1}	171.81	20.56	151.26
T_8 – 100% RDF through soil application + Pressmud @ 5 t ha^{-1}	160.30	19.18	141.12
T_9 – 100% RDF through drip fertigation + Pressmud @ 5 t ha^{-1}	171.07	20.47	150.60
SEd	4.00	0.45	3.45
CD (p=0.05)	8.47	0.96	7.32

to increased root growth, which in turn advances the absorbing water and nutrients in the soil, leading to higher build-up DMP by plants[8]. Lower DMP (6298 kg ha^{-1})was registered under control (T_1) during the harvest.

Crop growth rate (CGR) and Absolute crop growth rate (AGR) :

The crop growth rate denotes the increase in crop DMP per unit of land area per unit of time. The increase in size of plants over a given time period can be determined by Absolute crop growth rate.Among the treatments, application of 100% RDF through fertigation + Vermicompost @ 5 t ha^{-1} (T_7) recorded higher growth analysis parameters *viz.*, CG Rduring 60 DAS to harvest (15.61g m^{-2} day^{-1}), AGR during 60 DAS to harvest (1.99cm $plant^{-1}$ day^{-1}). This treatment wasclose to T_9 - 100% RDF through fertigation + Pressmud @ 5 t ha^{-1}. This could occur as a consequence of ingesting the entire quantity of recommended amount of fertilizer through fertigation along with organic manures, which increased nutrient availability and absorption by producing growth-promoting compounds and a greater quantity of dry matter causes the improvement in maize plant growth[11]. Lower CGRduring 60 DAS to harvest (7.55g m^{-2} day^{-1}) and absolute crop growth rate during 60 DAS to harvest (0.57cm $plant^{-1}$ day^{-1})were recorded in the treatment control (T_1).

Yield attributes :

Effect of organic manures and strategies of fertilizer application of fertilizer strategies showed significant effects on the yield characteristics of maize (Table-2).

Total number of grains cob^{-1} :

The treatment with administration of

100% RDF through fertigation + Vermicompost @ 5 t ha^{-1} (T_7) was discovered to produce higher yield attributes i.e., number of grain row cob^{-1} (13.12), number of grains row^{-1} (23.82) and total number of grains cob^{-1} (312.52) and this treatment was on par with the application of 100% RDF through fertigation + Pressmud @ 5 t ha^{-1} (T_9). The number of grain row cob^{-1}, number of grains row^{-1} and total number of grains cob^{-1} showed to be highly significant among the treatments used in the trial. This may be owing to the great performance of water soluble fertilizers, accessibility to plant nutrients, and combined effects of organic and inorganic fertilizer, which is responsible for a substantial increase in the number of grains producedcob^{-1}, [2]. A lower yield parameters viz., number of grain row cob^{-1} (7.78), number of grains row^{-1} (14.71) and total number of grains cob^{-1} (114.44) was recorded in the treatment control (without fertilizer application).

Cob weight :

The cob weight per plant revealed that, significant difference occurred among the different treatments used in the trial. Administration of 100% RDF through fertigation + Vermicompost @ 5 t ha^{-1} (T_7) recorded with maximum cob weight $plant^{-1}$ (83.59 g) and test weight (24.19 g). This was on par with the treatment 100% RDF through fertigation + Pressmud @ 5 t ha^{-1} (T_9). This could be as a result of sustained nutritional application which enhanced supply of nutrients from vermicompost, which have increased nutrient uptake and improved nutrient translocation resulted in improving cob weight. The similar outcomes on increased cob weight as a result of improved nutrient management techniques together with vermicompost application in contrast to conventional methods of soil application[14]. The treatment control (T_1) was found to producelowercob weight (30.72 g) and test weight (24.05 g).

Grain and stover yield :

Diverse organic manures and fertilizer application processes exhibited significant consequenceson the crop yield of maize (Table-3).

Out of all the alternative fertilizer administration strategies, the treatment with 100% RDF through fertigation+ Vermicompost @ 5 t ha^{-1} (T_7) yielded the biggest grain yield (6193 kg ha^{-1}), stover yield (9769 kg ha^{-1}) and harvest index (38.80) (Fig. 3). This treatment was the same as 100% RDF through fertigation + Pressmud @5 t ha^{-1} (T_9). This could be due to the addition of a wider range of fertilizer types during fertigation, which raised the supply of critical nutrients consisting of NPK, which is in soil solution, resulting in elevated absorption along with greater assimilating of nutrients from sources and sinking, boosting yield traits and yield. The similar finding reported on grain yield and stover yield[4].The treatment control (T_1) recorded lower grain yield (2270 kg ha^{-1}), stover yield (4250 kg ha^{-1}), and harvest index (34.82). This might be due to crop plants having less access to nutrients, which along with poor yield-enhancing characteristics had resulted in lower production[18].

Nutrient uptake :

Organic manures and fertilizer

application techniques showed substantial impacts on the NPK uptake by maize (Table-4).

Across the different organic manures and fertilizer application methods, the treatment with 100% RDF through fertigation + Vermicompost @ 5 t ha^{-1} (T_7) led to higher nitrogen (171.81 kg ha^{-1}), phosphorus (20.56 kg ha^{-1}), and potassium (151.26 kg ha^{-1}) absorption rates (Fig. 4). This treatment was close to 100% RDF through fertigation + Pressmud @ 5 t ha^{-1} application (T_9). This might due to continuous fertilizer delivery and improved root activity; nutrients are more readily available in the region around the roots. In addition, this was due there was less nutrient loss from leaching in fertigation as compared to fertilizer applied to the soil. It is clearly shown by the LAI and DMP values. In maize plants grown with drip fertigation, taller plants that have a higher LAI provided greater DMP and nutrients absorption[16]. The treatment control recorded lower nitrogen (70.54 kg ha^{-1}), phosphorus (8.82 kgha^{-1}) and Potassium (64.87kg ha^{-1}) uptake.

In this present study with effect oforganic manures and various methods of fertilizer application techniques, application of 100% RDF through fertigation + Vermicompost @ 5 t ha^{-1} observed better growth characters *i.e.,* plant height, LAI, LAD, DMP, CGR, AGR, yield parameters*i.e.,*number of grain rows cob^{-1}, number of grains row^{-1}, total grains cob^{-1}, cob weight, test weight, grain yield, stover yield, harvest index and NPK absorption rate by maize when compared to soil application of NPK fertilizers. It has been determined that this fertigation method, in combination with the addition of vermicompost might be a practicallysuitable method in maize for enhancing grain production, as well as potentially being profitable for maize growers.

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Conflicts of interest

The authors report no conflicts of interest in this work.

Ethical approval

This study does not involve any experiments on human or animal subjects.

Data availability :

All data generated and analysed or included with in the research.

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