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RESEARCH ARTICLE

Influence of Organic Manures and Synthetic Fertilizers on Nutrient Uptake and Yield of Fodder Maize

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ABSTRACT

A pot culture experiment was conducted at the Department of Agronomy, Madras Veterinary College, Chennai during rabi season 2019 - 2020 to study the influence of organic manures and synthetic fertilizers on the nutrient uptake and green fodder yield of fodder maize (*Zea mays* L.). An experiment was laid out with two factors and three replications. Four organic manure treatments in main-plots *viz.,* no manure, farm yard manure (25 t ha^{-1}), vermicompost (12 t ha^{-1}) and poultry manure (12 t ha^{-1}) and four fertilizer treatments in subplots *viz.,* No fertilizer, 125% RDF, 100% RDF, 75% RDF. The recommended dose of fertilizer (RDF) for fodder maize is 60 kg N ha^{-1}: 40 kg P_2O_5 ha^{-1}: 20 kg K_2O ha^{-1}. The organic manures were applied as per the N equivalent basis to the inorganic nutrient recommendation. The results revealed that the application of nutrients through poultry manure @ 12 t ha^{-1} resulted in higher plant uptake of Nitrogen (112.2 kg ha^{-1}), phosphorus (19.26 kg ha^{-1}), and potassium (117.7 kg ha^{-1}) followed by the application of farm yard manure @ 25 t ha^{-1} on N equivalent basis. Concerning fertilizers, the application of 75% recommended dose of inorganic fertilizer resulted in higher plant nitrogen, phosphorous and potassium uptake (104.9, 18.9, 108.54 Kg ha^{-1} N, P, K, respectively). About the fodder yield, the highest green and dry fodder yield were recorded under the treatment combination of poultry manure along with 75% RDF 31.84 t ha^{-1} and 5.19 t ha^{-1} at 60 DAS, respectively.

Keywords: *Nutrient uptake; Fodder yield; Organic manure; Inorganic fertilizers; Fodder maize*

INTRODUCTION

Maize (*Zea mays*) is the most crucial crop among cereals having a wider adaptability to varied agro-climatic conditions. It is an ideal forage crop as it proliferates, produces high yields, and is palatable and rich in nutrients (Iqbal *et al.,* 2006). It is the crop having the highest productivity and is an excellent crop in terms of biomass production. Maize is free from anti-nutritional components and a valuable fodder crop. It contains high concentrations of protein and minerals, highly digestible, and helps increase body weight and milk quality in cattle (Chaudhary *et al.,* 2014).

The economics of milk and meat production largely depend on the quality of nutritious fodder fed to animals. Feeding green forages, compared to concentrates, substantially lowers the cost of livestock production. For optimum milk production, around 25 kg of green fodder is required to feed per animal per day. However, a huge deficit exists between India's demand and supply of green fodder. As per the estimates of the National Institute of Animal Nutrition and Physiology (NIANP, 2020), the deficit in the availability of dry fodder and green fodder during 2020 was to the extent of 23 per cent and 32 per cent, respectively. Due to a deficit of green fodder, farmers are feeding low quantities of green fodder to livestock, affecting their health, breeding, and milk yield.

To meet the needs of the ever-increasing livestock population, the production and productivity of fodder needs to be increased. However, the increasing cultivation of cereal and cash crops contributed to a decline in the area under fodder cultivation. There is tremendous pressure on livestock on the available, total feed and fodder, as the land available for fodder production has been decreasing. Therefore, by cultivating maize fodder, it provides sufficient quantities of green fodder, instead of costly concentrates for the livestock. Livestock production costs will be reduced, and animal health will be improved.

Fertilization is a method to provide and supply the nutrients of fodder maize. N, P, and K nutrients are essential for plants; they must always be available in

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the soil. Farmers usually apply inorganic fertilizers in excessive amounts. It leads to physical, chemical and biological damage to soil and decreases soil fertility. Efforts might be made to reduce the negative impact of inorganic fertilizers that can improve soil properties and increase the nutrient content of the soil (Sofyan *et al.,* 2019).

The use of organic inputs such as manure and compost has great potential to improve soil productivity and crop yield through the improvement of the physical, chemical and microbiological properties of the soil as well as nutrient supply (Stone and Eliff, 1998). However, the use of organic manures in maize fodder cultivation was not explored sufficiently. Hence, considering the above points, the present study was undertaken to investigate the impact of organic fertilizer combined with inorganic fertilizer on N, P and K nutrient uptake and yield of fodder maize.

MATERIAL AND METHODS

Pot culture experiments were conducted at the Department of Agronomy, Madras Veterinary College, Chennai in 2019 and 2020 to study the effect of organic manures and synthetic fertilizers on nutrient uptake and yield of fodder maize. The experiment was laid out in a factorial completely randomized block design with three replications. Four organic manures *viz.,* no manure, farm yard manure (25 t ha^{-1}), vermicompost (12 t ha^{-1}) and poultry manure (12 t ha^{-1}) were the treatments under factor 'A'. Four fertilizer treatments *viz.,* No fertilizer, 125% RDF, 100% RDF and 75% RDF were included under factor 'B'. The recommended dose of fertilizer (RDF) for fodder maize was 60: 40: 20 Kg NPK ha^{-1}, respectively. The soil-applied for the pot culture experiment was red sandy loam in texture belonging to Typic Ustropept. The organic manures were used as per the N equivalent basis to the inorganic nutrient recommendation. The nutrient status of the soil was low in available nitrogen (128.5 kg ha^{-1}), medium in available phosphorus (25.3 kg ha^{-1}), and medium in available potassium (226.3 kg ha^{-1}). Fodder maize variety African tall was chosen for the study.

Random samples of FYM, Vermicompost, and poultry manure were collected from the bulks separately, air-dried, ground, sieved and analyzed before the start of the experiment *viz.,* total organic C, total N, total P, total K and C:N ratio (Chapman and Pratt, 1961) and applied in pots as per the treatments. Composition of organic manures used in the experiment is given in the Table 1.

The pots were filled with soil, after which fodder maize seeds were sown at a rate of 5 seeds per pot in all the experimental pots. The quantities of organic and inorganic fertilizers were calculated based on the nutrient availability in their nutrient sources as well as the quantity of soil used in the pots. The quantity of organic manures applied was 12.82 g, 8.57 g and 8.12 g pot^{-1} as farm yard manure, vermicompost, and poultry manure, respectively. All the organic manures were applied as basal and inorganic fertilizers were applied in the form of Urea (46 % N), Single super phosphate (16 % P_2O_5) and Muriate of potash (60 % K_2O) in all pots. Nitrogen was applied in two splits *viz.,* 50: 50 per cent as basal and on 30 DAS, respectively. The entire dose of phosphorus and potassium was applied basally. Growth and yield parameters were recorded by sampling the grown plants.

Plant samples were dried out at 65ºC to the constant weight and grounded for further analyses. Total nitrogen concentration in the plant material was determined by the micro Kjeldahl method as per the procedure given by Yoshida *et al.* (1971). P concentrations were assessed in ground plant material and mineralized at 550 ºC for 6 hours. Next, the ash obtained was mixed with diluted HN03 (concentrated nitric acid and distilled water 1:1). Phosphorus was determined calorimetrically with vanadium ammonium molybdate (Olsen and Sommers, 1982). Potassium concentration was assessed by the FAAS method (Flame Atomic Absorption Spectrophotometry) Jackson (1973).

Nutrient uptake was calculated based on dry weight values multiplied by nutrient concentration in plant samples and expressed in kg ha^{-1}. The fodder maize was harvested at 65 days after sowing and green fodder yield was recorded. After that, the samples were dried in a hot air oven at 65 °C for 48 hours and dry fodder yield was recorded.

Green fodder yield: The plants were freshly cut from the base and weighed with the help of a weighing machine from each plot having different treatments and computed to t ha^{-1} to obtain the green fodder yield of maize.

Dry fodder yield: The samples were dried in hot air oven at 65 °C for 48 hours and oven dried sample were weighed with the help of a weighing machine taken from each net plot having different treatments and computed to t ha^{-1}. Data obtained from all the parameters were subjected to statistical analysis using ANOVA (Analysis of variance) outlined by Panse and Sukhatme (1985). F-value was tested at 5 per cent level of significance.

RESULTS AND DISCUSSION

Nutrient uptake

The application of organic manures and inorganic fertilizers significantly influenced the nutrient uptake of fodder maize during the study years. The nitrogen, phosphorus, and potassium uptake of fodder maize is presented in Table 2.

In respect of organic manures, application of nutrients through poultry manure @ 12 t ha^{-1} resulted in higher plant uptake of Nitrogen, Phosphorus and Potassium (112.2, 19.26 and 117.7 kg N, P, K, respectively) followed by application of farm yard manure @ 25 t ha^{-1} on an N equivalent basis. This could be attributed to the release of nutrients by the poultry manure upon decomposition and increased the concentration of the macro nutrient in plant organs due to better root establishment, resulting in higher absorption of nutrients by maize plant and, in turn, increased the growth and dry weight of plants lead to higher green fodder yields. Nutrient uptake is the function of yield, and nutrient concentration and yield are the deciding factor for higher nutrient uptake. Lakum *et al.* (2020) made similar observations on maize nutrient uptake (N, P and K) in the experimental area. The control plots recorded lesser nitrogen, phosphorous and potassium uptake by fodder maize.

Concerning fertilizers, the application of 75% recommended dose of inorganic fertilizer resulted in higher plant nitrogen, phosphorous and potassium uptake (104.9, 18.9, 108.54 Kg N, P, K, respectively) but comparable with the application of 100% recommended dose of inorganic fertilizer to the fodder maize. This might be due to the increased absorption of nutrient by fodder maize as well as improvement in the growth characteristics with the application of inorganic fertilizer. The least nutrient uptake was found with the treatment without fertilizer application to the fodder maize crop.

The treatment combination of poultry manure @ 12 t ha^{-1} + 75% recommended dose of inorganic fertilizer to fodder maize recorded higher Nitrogen, phosphorous and potassium uptake (122.5, 22.23 and 128.45 kg N, P, K, respectively) followed by poultry manure + 100% recommended dose of inorganic fertilizer to fodder maize. The least nutrient uptake was recorded under fodder maize grown in the plots without nutrient application. The combined application of organic manures and inorganic fertilizers increased the nutrient uptake, which might have been due to the balance availability of nutrients to the maize plants that resulted in a favorable soil environment. These favorable conditions increased the nutrient availability and water-holding capacity resulting in enhanced growth and yield of fodder maize. Rashid *et al.* (2013) also reported that an increased supply of Nitrogen resulted in increased plant N content and nitrogen uptake by Stevia.

Fodder Yield

Pooled data on green and dry fodder yield significantly affected by organic and inorganic fertilizer levels at 30, 45 and 60 DAS (Fig 1 & 2). Application of poultry manure improved green matter content in plants and higher green fodder yield was found with the application of poultry manure (12 t ha^{-1}) at 30 DAS (11.13 t ha^{-1}), 45 DAS (21.17 t ha^{-1}) and 60 DAS (28.22 t ha^{-1}) followed by farm yard manure application (25 t/ha). With regard to dry fodder, the highest dry fodder yield (2.99, 4.07, 4.66 t ha-1 at 30, 45 and 60 DAS, respectively) was recorded with the application of poultry manure @ 12 t ha^{-1}. This may be due to the fact that organic manure might have high amount of nitrogen, phosphorous and potassium content and is gradually available to the crops at all the stages of growth than the mineral fertilizer, and its effect on the soil was stable, also improved the soil physical and chemical properties, and thus increased the yield of maize. This agrees with the findings of Okoroafor *et al.* (2013). However, the lowest green and dry fodder yield were recorded in control plots at all the stages.

Among the fertilizer levels, 75% RDF recorded the highest green fodder yield (9.64, 19.84, 27.07 t ha-1 at 30, 45 and 60 DAS, respectively) and dry fodder yield (2.61, 3.19 and 4.32 at 30, 45 and 60 DAS, respectively) followed by 100% RDF. Further increase in fertilizer level to 125% RDF did not increase green fodder yield, which was comparable with the application of 100% RDF. The control plots recorded the least green fodder yield than the other treatments. Macronutrients are the essential elements responsible for enhancing plant morphological and physiological traits, *viz*. shoot development, foliage emergence, and dry matter accumulation. Therefore, fertilizer level of 75 % RDF is sufficient to stimulate vegetative growth, resulting in higher green fodder yield. The results were similar to the earlier findings of Kasinath (2014) and Rama Bharti *et al.* (2019).

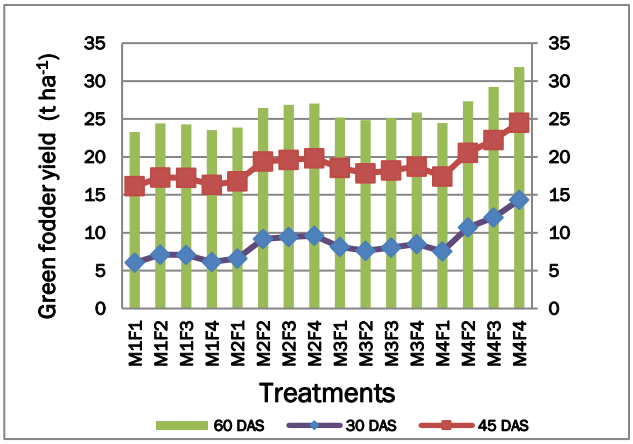

Fig 1. Interaction effect of organic manures and inorganic fertilizers on green fodder yield (t ha^{-1}) of fodder maize

The interaction between organic manures and fertilizer levels was significant at all stages. The highest green and dry fodder yield were recorded under the treatment combination of poultry manure along with 75% RDF (31.84 t ha^{-1} and 5.19 t ha^{-1} at 60 DAS, respectively), followed by poultry manure along with 100% RDF, and this was comparable with the poultry manure at 12 t ha^{-1} along with 125% RDF. The least green fodder yield was obtained under treatment without nutrient application (23.27 t ha^{-1} and 3.05 t ha^{-1} at 60 DAS, respectively). This increase in the green fodder yield may be due to an increase in plant height and leaf area index with the application of poultry manure and fertilizer. Application of poultry manure 12 t ha^{-1} was observed to substitute and modify the crop response to fertilizers, thereby; exhibiting interaction between these two sources of nutrients.

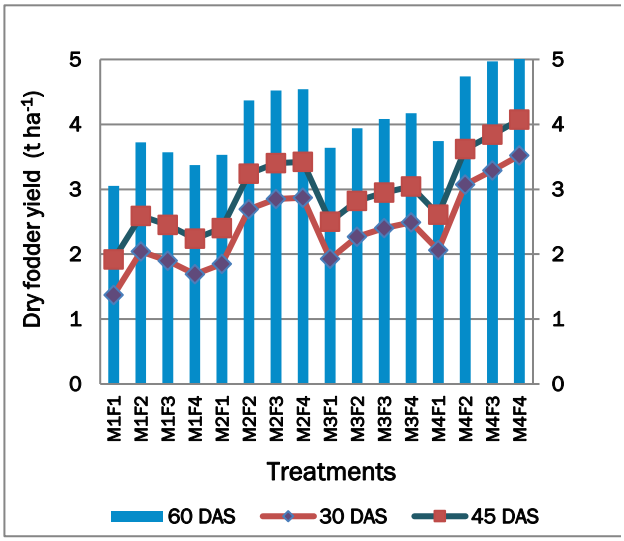

Fig 2. Interaction effect of organic manures and inorganic fertilizers on dry fodder yield (t/ha) of fodder maize

The poultry manure used contains a higher percentage of macronutrients *viz.,* 1.85% N, 0.68% P_2O_5 and 1.12% K_2O, so besides improving soil physical conditions for better growth and development, it might have supplied balanced nutrients to the crop. Hence, the application of poultry manure enhanced crop response to available nitrogen in the manure. The response of maize fodder to the application of 75 % RDF in the presence of poultry manure may be attributed to the synergistic effect of both organic and inorganic nutrients, resulting in enhanced growth of the crops (Mahmooda Buriro *et al.,* 2014). Higher green fodder yield was due to the cumulative improvement in growth parameters of maize crops.

This study's results agree with those of Silva *et al.* (2006). Rao and Shaktawat (2002) reported that commercial fertilizer in the form of urea for supplying N to the plants is commonly used, whereas organic material from manures can markedly increase soil productivity by providing essential plant nutrients and by improving the physical properties of soil. Kanchikerimath and Singh (2001) also reported that crop yields are improved if organic manure is supplemented with mineral fertilizers obtained with the combined application of poultry manure @ 12 t ha^{-1} and 75 % recommended dose of fertilizer.

CONCLUSION

It is evident from the above results that fodder maize grown under the application of poultry manure @12 t ha^{-1} on N equivalent basis recorded the maximum uptake of nutrients such as nitrogen, phosphorus and potassium followed by application of Farm Yard Manure. With respect to inorganic fertilizers, the application of 75% recommended dose of fertilizer resulted in higher plant nitrogen, phosphorous and potassium uptake. The treatment combination of poultry manure and 75% RDF to fodder maize recorded the highest green and dry fodder yield at 60 DAS under Eastern Zone of Tamil Nadu.

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Ethics statement

There is no human or animal subjects were involved in this research, because it was a field experiment.

Originality and plagiarism

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Consent for publication

We both authors are agreed to publish the content.

Competing interests

There was no conflict of interest in the publication of this content.

Data availability

All the data of this manuscript are included in the MS. No separate external data source is required.

Author contributions

Research grant – Both author, Idea conceptualization- Both author, Experiments – Both author, Writing original draft – First author; Writing-reviewing &editing- First and co-author.

Table 1. Composition of organic manures used in the experiment

Nutrient source	Total organic carbon (%)	C:N	Total Nitrogen (%)	Total Phosphorus (%)	Total Potassium (%)
Farm Yard Manure	16.7	19.0	1.17	0.40	0.69
Vermicompost	19.4	18.0	1.75	0.59	0.95
Poultry manure	21.3	20.0	1.85	0.68	1.12

Table 2. Effect of organic manures and inorganic fertilizers on nutrient uptake (kg ha-1) of fodder maize at harvest stage

Treatments	Nitrogen					Phosphorus					Potassium				
	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean	F_1	F_2	F_3	F_4	Mean
M_1	83.7	90.5	88.2	84.2	**86.7**	16.66	17.69	17.46	16.82	**17.16**	83.16	95.78	93.25	84.79	**89.25**
M_2	86.5	105.4	108.5	110.5	**102.7**	17.35	18.24	18.28	18.34	**18.05**	90.48	110.44	111.84	115.46	**107.06**
M_3	86.8	95.8	98.5	102.5	**95.9**	17.28	18.06	18.14	18.21	**17.92**	88.30	100.19	103.24	105.46	**99.30**
M_4	92.5	114.8	119.0	122.5	**112.2**	17.99	18.39	18.46	22.23	**19.26**	98.69	119.45	124.36	128.45	**117.74**
Mean	**87.4**	**101.6**	**103.5**	**104.9**		**17.32**	**18.10**	**18.09**	**18.90**		**90.16**	**106.47**	**108.17**	**108.54**	
	M	**F**	**M at F**			**M**	**F**	**M at F**			**M**	**F**	**M at F**		
SE	2.68	2.06	4.12			0.319	0.416	0.831			2.788	2.135	4.271		
CD (p=0.05)	6.56	4.25	8.51			0.781	0.858	1.716			6.822	4.407	8.815		

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