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Influence of Organic Manures and Inorganic Fertilizers on Growth and Yield of Fodder Maize (*Zea mays* L.) Grown in North Eastern Zone of Tamil Nadu

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Authors' contributions

This work was carried out in collaboration between both authors. Author TA designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author CV managed the literature searches and analyses of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Experiments were conducted during *rabi* season of 2019 and 2020 at the Department of Agronomy, Madras Veterinary College, Chennai to assess the performance of fodder maize (*Zea mays* L.) under varying combinations of organic manures and inorganic fertilizers. An experiment was laid out in split plot design with four organic treatments in main-plots *viz*., No manure, farm yard manure (25 t/ha), vermicompost (12 t/ ha), poultry manure (12 t /ha) and four fertilizer treatments in subplots with levels of No fertilizer, 125% RDF, 100% RDF, 75% RDF. Recommended dose of fertilizer (RDF) for fodder maize crop 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 inorganic nutrient recommendation. The results revealed that all the maize growth parameters, green and dry fodder yield were significantly affected with the application of organic manures and fertilizer levels. Growth parameters *viz.,* taller plants, more number of leaves per plant, higher leaf area index, stem girth, leaf stem ratio were observed

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under the combined application of poultry manure @ 12 t/ha and fertilizer level of 75% RDF. The highest green matter yield and dry fodder yield were recorded with the integrated application of poultry manure @ 12 t/ ha along with the fertilizer level of 75 % RDF.

Keywords: Leaf area; leaf area index; leaf stem ratio; stem girth; poultry manure.

1. INTRODUCTION

Green fodder is an important component of animal feed. The growth of livestock sector primarily depends upon the availability of nutritious fodder. Maize is one of the most nutritious non-legume green fodders. The high acceptability of maize as fodder can be judged from the fact that it is free from any anti-nutritional components. Maize is quick growing, yields high biomass, and is highly palatable. It contains sufficient quantities of protein and minerals and possesses high digestibility as compared to other non-legume fodders [1].

The fodder production in our country is insufficient to meet the requirement of livestock in the country. According to agricultural research data (2018) [2] total deficit of green and dry fodder was estimated as 11.24 % and 23.40 % respectively. Since, feeding alone accounts for two-third of the total cost in animal production. It is essential to reduce the total cost of feed and could only be achieved by providing sufficient quantity of green fodder to livestock total population. For increasing the production of quality fodder, nutrient management through conjoint use of organic and inorganic plant nutrient sources is very crucial.

On the other hand, use of organic manure is slow releasing and could hardly supply the quantity of nutrients needed by crops [3]. Application of organic manure to meet the nutrient requirement of crop would be an inevitable practice since organic manures generally improve the soil physical, chemical and biological properties along with conserving capacity of the moisture holding capacity of soil and this, resulting in enhanced crop productivity along with maintain the quality of crop produce [4]. Although organic manures contain plant nutrients in small qualities compared to inorganic fertilizers, the presence of growth promoting principle like enzymes and hormones, besides plant nutrient make them essential for improvement of soil fertility and productivity [5].

In order to make the soil well supplied with all the plant nutrients in the readily available form and to maintain good soil health, it is necessary to use organic manures in conjunction with inorganic fertilizers to obtain optimum yields Khidrapure et al. [6] and Vajinder pal kalra and sharma [7].

On the other hands studies using organic nitrogen source to improve forage production were limited to the use of the farmyard manure. The animal manure is abundantly available so it is considered as a cheapest source of nitrogen for crops fertilization compared to inorganic source as urea. Therefore, the present study was undertaken to study the effect of different organic manures and inorganic fertilizers on growth and yield of fodder maize.

2. MATERIALS AND METHODS

2.1 Site Description and Treatments

The experiments were conducted at the Department of Agronomy, Madras Veterinary College, Chennai during 2019 and 2020. The institute is located in the North Eastern agro-ecological zone of Tamil Nadu at 13.04^0 N latitude, 80.17^0 E longitude and at an altitude of 6.7 M.A.S.L.The mean annual rainfall of the zone varies from 800-1400 mm. The mean maximum and minimum temperatures were 29 and 41.9°C during 2019-2020. The mean annual rainfall recorded was 999 mm during 2019-20 with an average relative humidity of 70%. The soil applied in the pot is red soil. The soil of was classified as medium for available nitrogen, phosphorus and potassium, respectively. The physio chemical properties of the soil at experimental sites are presented in Table 1.

Table 1. Physio chemical properties of the soil before experiment

Soil characteristics	Values
Textural class	Typic Ustropepts
Field capacity (%)	16.73
Bulk density (g cc^{-1})	1.52
Permanent wilting point (%)	8.46
Organic carbon (%)	0.26
Available nitrogen (kg ha^{-1})	128.5
Available phosphorus (kg ha^{-1})	25.3
Available potassium (kg ha^{-1})	226.3
pH	7.43
Electrical conductivity (dSm^{-1})	0.28

Random samples of FYM, Vermi compost and poultry manure were collected from the bulks separately, air-dried, ground, sieved and then analyzed for dry matter, total organic C, total N, total P, total K and C:N [8]. Composition of organic manures used in the experiment is given in the Table 2.

An experiment was laid out in split plot design with four organic treatments in main-plots *viz*., No manure, Farm Yard Manure (25 t/ha), Vermicompost (12 t/ ha), Poultry Manure (12 t /ha) and four fertilizer treatments in subplots with levels of No fertilizer, 125% RDF, 100% RDF, 75% RDF. Recommended dose of fertilizer (RDF) for fodder maize crop is 60 kg N ha^{-1}: 40 kg P_2O_5 ha^{-1}: 20 kg K_2O ha^{-1} as per recommendations of TNAU Crop Production Guide, 2012. The organic manures were applied as per the N equivalent basis to inorganic nutrient recommendation. The fodder maize Var. African tall was used for the study. In the plots, the treatments and replications were assigned at random to minimize the experimental error. Randomization of treatment plots was done according to statistical methods.

2.2 Growth and Yield

Growth and yield parameters recorded at different stages of crop growth and development were: Plant height, number of leaves per plant, stem girth, leaf area index, leaf stem ratio, green matter yield and dry matter yield at 15, 30, 45 and 60 DAS. These parameters were determined in the following ways: Plant height: This was taken from a sample of three randomly selected maize plants marked within each plot. A carpenter's tape was used for measuring the height from the ground level to the top-most leaf. The mean from the three plants was then determined. Number of leaves: Visual counting of leaves on the three randomly selected plants was made and the number was recorded for each plant. The mean values were then calculated for each plot. Stem girth: The stem girth of the three selected maize plants was measured with a thread and the actual measurements were determined on a carpenter's tape in centimeter for each plot and the values were averaged. Leaf area: The leaf area was determined by the non-destructive length x width method [9] using the relation: Leaf area = 0.75 (length x width), where 0.75 is a crop constant. Three leaves were measured with a tailor's tape for each plot and the leaf area was determined. Green fodder yield: The plants were freshly cut from the base and weighed with the help of weighing machine from each plot having different treatments and computed to t ha^{-1} to obtain green fodder yield of maize. Dry fodder yield: The samples were dried in hot air oven at 65°C for 48 h and oven dried sampled plants were weighted with the help of 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 by means of ANOVA (analysis of variance)outlined by Panse and Sukhatme [10]. F value was tested at 5percent level of significance.

3. RESULT AND DISCUSSION

3.1 Growth Attributes

Plant height, number of leaves, stem girth, leaf area index and leaf stem ratio were significantly influenced by the organic manures and fertilizer levels at all the stages of observation

3.1.1 Plant height and number of leaves

The pooled data on plant height and number of leaves of fodder maize to different organic manures and fertilizers are shown in Table 3 and 4. There were gradual increases in plant height of maize from 15 - 45 Days after sowing. Among the organic manures, plants that received poultry manure recorded taller plants (60, 100.6, 127.5 and 170.7 cm at 15, 30, 45 and 60 DAS, respectively) and maximum number of leaves (6.91, 7.82, 11.25 and 10.54 at 15, 30, 45 and 60 DAS, respectively) followed by application of farm yard manureon N equivalent basis. The least plant height was observed under the control which were grown without manure at all the stages.

Plants that received poultry manure grew taller than other plants, possible because more concentrated nutrients or minerals were made readily available and easily absorbable by the receiving plants leading to faster growth and development. This is harmony with the findings of Enujeke [11]. It is similar to the findings of Fagimi and Odebode [12] who reported increased plant height and number of leaves of pepper resulting from application of higher rate of poultry manure.

With regard to fertilizer levels, data (Tables 1 & 2) indicates that the plant height and number of leaves at different stages of growth showed

significant increase with fertilizer level of 75 % RDF compared to 100% RDF however, the fertilizer level 125% RDF did not differ from 100% RDF. The unfertilized plot recorded the least plant height at all the stages of observation. Fertilizer level 75% RDF might have provided sufficient nitrogen to the crop for rapid cell division and cell elongation thereby resulting in increased plant height. Shamim et al. [13] reported significant increase in the plant height of maize with fertility level up to 75 kg N ha^{-1}. However, 90 kg N ha^{-1} did not prove to enhance the growth parameters of maize crop.

Table 2. 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	1.17	0.40	0.69
Vermicompost	19.4	18	1.75	0.59	0.95
Poultry manure	21.3	20	1.85	0.68	1.12

Table 3. Effect of organic manures and inorganic fertilizers on pooled plant height (cm) of fodder maize

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
Organic manures				
M_1 - No manure	40.7	78.3	97.9	130.2
M_2 - Farm yard manure	54.0	91.6	116.2	156.5
M_3 - Vermicompost	52.0	85.7	111.9	146.4
M_4 - Poultry Manure	60.0	100.6	127.5	170.7
SEm	1.46	2.17	3.39	6.31
CD (P = 0.05)	**3.57**	**5.32**	**8.30**	**15.44**
Fertilizer levels				
F_1 - No fertilizer	40.4	78.9	98.2	131.6
F_2 - 125 % RDF	53.0	91.4	117.0	154.6
F_3 - 100 % RDF	55.1	92.5	118.0	158.6
F_4 - 75 % RDF	58.1	93.4	120.2	158.9
SEm	1.06	1.96	2.87	4.35
CD (P = 0.05)	**2.19**	**4.05**	**5.92**	**8.97**
Interaction	NS	NS	NS	NS

Table 4. Effect of organic manures and inorganic fertilizers on pooled number of leaves of fodder maize

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
Organic manures				
M_1 - No manure	6.07	7.10	9.73	9.76
M_2 - Farm yard manure	6.58	7.54	10.35	10.12
M_3 - Vermicompost	6.41	7.33	10.14	10.03
M_4 - Poultry Manure	6.91	7.82	10.74	10.54
SEm	0.173	0.184	0.271	0.138
CD (P = 0.05)	**0.423**	**0.451**	**0.663**	**0.338**
Fertilizer levels				
F_1 - No fertilizer	6.14	7.15	9.80	9.76
F_2 - 125 % RDF	6.55	7.47	10.34	10.12
F_3 - 100 % RDF	6.65	7.58	10.38	10.03
F_4 - 75 % RDF	6.62	7.59	10.44	10.54
SEm	0.138	0.162	0.219	0.174
CD (P = 0.05)	**0.285**	**0.333**	**0.452**	**0.359**
Interaction	NS	NS	NS	NS

3.1.2 Leaf area index

The pooled data on leaf area index of maize to organic manures and fertilizer levels are shown in Table 4. There were significant differences in leaf area index of maize in both years of evaluation.

Among the organic manures, the plots applied with poultry manure recorded higher LAI at all the stages *viz.,* 30, 45 and 60 DAS, followed by farm yard manure application. This might be due to increase in carbon content, water holding capacity, aggregation of soil and decrease of bulk density, with the application poultry manure @ 12 t/ha, all of which interplay to increase leaf area and total chlorophyll content of maize. This is consistent with the findings of Amujoyegbe et al. [14] who reported that application of poultry manure enhanced leaf area, total chlorophyll content, carbon content, water holding capacity of soil which culminate and interplay to promote yield. The least LAI was recorded in the control plots in both years of evaluation.

Among the fertilizer levels, 75 % RDF recorded higher LAI at 30, 45 and 60 DAS with values of 1.44, 3.4, 5.43 and 4.61 respectively, followed by 100% RDF at all the stages of observation and it was comparable with 125% RDF. The unfertilized plot recorded the least LAI at all the stages of observation. Maximum leaf area was recorded at all the stages at fertilizer level. Application of fertilizer level at 75% RDF level might have provided sufficient nitrogen to the crop for rapid cell division and cell elongation thereby resulting in increased leaf area. The decrease in leaf area index of crop irrespective of fertility levels after 45 days could be attributed to senescence of lower leaves.

3.1.3 Stem girth and leaf stem ratio

The result reveals that there was significant difference ($p<0.05$) among the treatments (Table 5 & 6). Application of poultry manure gave the highest stem girth (1.99, 3.93, 5.72 and 5.22 at 15,30, 45 and 60 DAS, respectively) and leaf stem ratio (1.16, 1.31, 0.91, 0.53 at 15,30, 45 and 60 DAS, respectively) of maize followed by farm yard manure application. The control plots recorded the least stem girth of maize at all the stages of growth. This might be due to the fact that poultry manure is an excellent nutrient source because of its high nitrogen, phosphorous and potassium content and readily available than the other manures and it improves the structure of the soil thereby increasing the vegetative growth as well as the stem girth and leaf stem ratio. This agrees with the finding of Okoroafor et al. [15].

Among the fertilizer levels, 75 % RDF produced higher stem girth and leaf stem ratio at 15,30, 45 and 60 DAS than 100 % RDF, however application of 125 % RDF was at par with application of 100% RDF during both years. The unfertilized plots recorded the least leaf stem ratio at all the stages of observation. Therefore, higher leaf to stem ratio with optimumfertilizer levels was due to accelerated and profuse leaf growth withhigher nutrient availability and nutrient uptake during the grand growth period.These findings are in close agreement with the findings of Bakht et al.[16].

Table 5. Effect of organic manures and inorganic fertilizers on pooled leaf area index of fodder maize

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
Organic manures				
M_1 - No manure	1.01	2.34	4.40	3.56
M_2 - Farm yard manure	1.34	3.00	4.78	4.28
M_3 - Vermicompost	1.23	2.63	4.60	4.00
M_4 - Poultry Manure	1.44	3.40	5.43	4.61
SEm	0.045	0.154	0.160	0.106
CD (P = 0.05)	**0.110**	**0.377**	**0.392**	**0.259**
Fertilizer levels				
F_1 - No fertilizer	1.02	2.32	4.43	3.64
F_2 - 125% RDF	1.32	2.94	4.88	4.24
F_3 - 100% RDF	1.35	3.02	4.89	4.29
F_4 - 75% RDF	1.33	3.09	5.00	4.30
SEm	0.035	0.093	0.128	0.089
CD (P = 0.05)	**0.072**	**0.192**	**0.263**	**0.183**
Interaction	NS	NS	NS	NS

Table 6. Effect of organic manures and inorganic fertilizers on pooled stem girth (cm) of fodder maize

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
Organic manures				
M_1 - No manure	1.52	3.32	5.05	4.08
M_2 - Farm yard manure	1.87	3.67	5.40	4.83
M_3 - Vermicompost	1.77	3.53	5.24	4.53
M_4 - Poultry Manure	1.99	3.93	5.72	5.22
SEm	0.075	0.161	0.174	0.146
CD (P = 0.05)	**0.182**	**0.395**	**0.427**	**0.358**
Fertilizer levels				
F_1 - No fertilizer	1.59	3.33	5.07	4.25
F_2 - 125 % RDF	1.84	3.68	5.38	4.77
F_3 - 100 % RDF	1.87	3.71	5.46	4.78
F_4 - 75 % RDF	1.86	3.72	5.48	4.85
SEm	0.089	0.148	0.135	0.144
CD (P = 0.05)	**0.184**	**0.305**	**0.279**	**0.297**
Interaction	NS	NS	NS	NS

Table 7. Effect of organic manures and inorganic fertilizers on pooled leaf stem ratio of fodder maize

Treatments	15 DAS	30 DAS	45 DAS	60 DAS
Organic manures				
M_1 - No manure	0.94	1.16	0.74	0.34
M_2 - Farm yard manure	1.11	1.27	0.86	0.46
M_3 - Vermicompost	1.03	1.23	0.80	0.44
M_4 - Poultry Manure	1.16	1.31	0.91	0.53
SEm	0.024	0.034	0.022	0.012
CD (P = 0.05)	**0.058**	**0.082**	**0.054**	**0.028**
Fertilizer levels				
F_1 - No fertilizer	0.95	1.17	0.74	0.35
F_2 - 125 % RDF	1.09	1.26	0.84	0.46
F_3 - 100 % RDF	1.10	1.27	0.86	0.48
F_4 - 75 % RDF	1.10	1.28	0.87	0.49
SEm	0.022	0.027	0.017	0.023
CD (P = 0.05)	**0.046**	**0.055**	**0.036**	**0.048**
Interaction	NS	NS	NS	NS

3.2 Fodder Yield

Pooled data on green and dry fodder yield was significantly affected by both organic and inorganic fertilizer levels at 15, 30, 45 and 60 DAS (Figs. 1 & 2).

Application of poultry manure improved green matter content in plants and higher green fodder yield was found with application of poultry manure (12 t /ha) at 15 DAS (6.03 t ha^{-1}), 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 (2.13, 2.99, 4.07, 4.66 t ha^{-1} at 15, 30, 45 and 60 DAS, respectively)was recorded with the application of poultry manure @ 12 t/ha. However, the lowest green and dry fodder yield was recorded in control plots at all the stages.

This agrees with the finding of Okoroafor et al.[15] who reported that organic manure is an excellent fertilizer material because of its high nitrogen, phosphorous and potassium content and gradually available to the crops at all the stages of growth than the mineral fertilizer and its effect on the soil is stable and also improving the soil physical and chemical properties and thus increased the yield of maize.

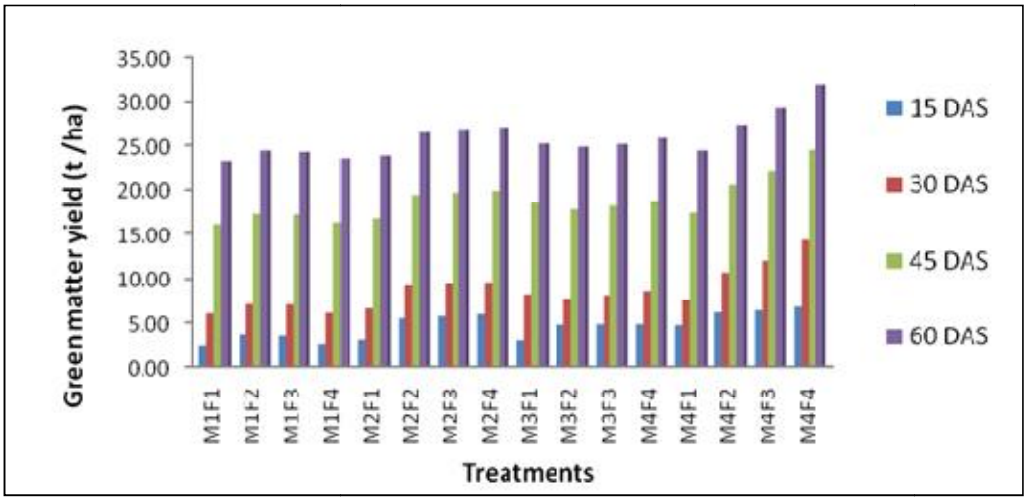

Fig. 1. Effect of organic manures and inorganic fertilizers on pooled green matter yield (t/ha) of fodder maize

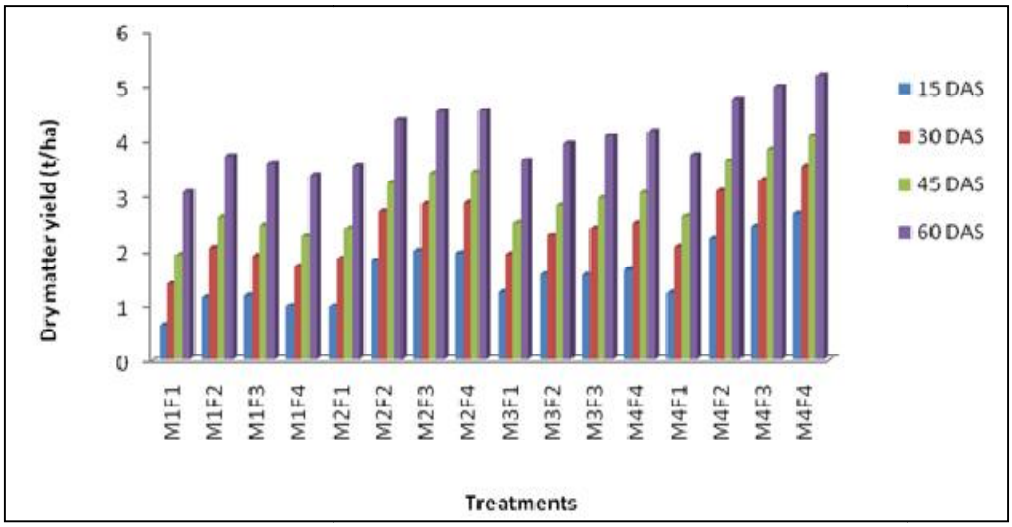

Fig. 2. Effect of organic manures and inorganic fertilizers on pooled dry matter yield (t/ha) of fodder maize

Among the fertilizer levels, 75% RDF recorded the highest green fodder yield (5.02, 9.64, 19.84, 27.07 t ha^{-1} at 15,30, 45 and 60 DAS, respectively) and dry fodder yield (1.81, 2.61, 3.19 and 4.32 at 15,30, 45 and 60 DAS, respectively) followed by 100% RDF. Further increase in fertilizer level to 125% RDF did not increase green fodder yield and this was comparable with the application of 100% RDF. The control plots recorded the least green fodder yield than the other treatments.

Macro nutrients are the essential elements responsible for the enhancement of morphological and physiological traits of plant *viz*. shoot development, foliage emergence and dry matter accumulation. Therefore, fertilizer level of 75 % RDF is sufficient to stimulate the vegetative growth and thereby resulted in higher green fodder yield. The results were similar with earlier findings of Kasinath [17] and Rama Bharti et al.[18].

The interaction between organic manures and fertilizer levels was significant at all the stages. The highest green and dry fodder yield was 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 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 dueto the cumulative effect of increase in plant height and leaf area index with application of poultry manure and fertilizer. Application of poultry manure 12 t/ha was observed to substitute and modify the crop responseto fertilizers, thereby; exhibiting interaction between these two sources of nutrients.

The poultry manure used contains higher percentage of macro nutrients 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 application of poultry manure enhanced crop response to available nitrogen of the manure. The response of maize fodder to 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 [19]. Higher green fodder yield was due to the cumulative improvement in growth parameters of maize crop.

The results of this study agree with those reported by Silva et al. [20]. Rao and Shaktawat [21] 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 plants nutrients and by improving physical properties of soil. Kanchikerimath and Singh [22] also reported that crop yields are improved if organic manure is supplemented with mineral fertilizers.

4. CONCLUSION

The study has revealed that the application of poultry manure @ 12t/ha on N equivalent basis was found significant for achieving higher plant height, number of leaves, leaf area index, stem girth and leaf stem ratio at different growth stages of fodder maize. Similarly, all the growth parameters were found significantly influenced by application of fertilizer at 75% RDF than all the other treatments. The highestgreen and dry fodder yield (31.84 t ha^{-1} and 5.19 t ha^{-1} was obtained with the combined application of poultry manure @ 12 t ha^{-1} and 75 % recommended dose of fertilizer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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