EFFECT OF FARMYARD MANURE ON BIOMASS YIELD, CARBON ASSIMILATION POTENTIAL AND CORRELATION COEFFICIENT IN FODDER MAIZE (*Zea mays* L.) IN DIFFERENT AGROCLIMATIC ZONES

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ABSTRACT

A field experiment was conducted to study the effect of inorganic fertilizer and the synergistic effect of farmyard manure (organic) with inorganic fertilizer on the Green Fodder Yield (GFY), Dry Matter Yield (DMY), Carbon Assimilation Potential (CAP) and Correlation Coefficient between soil organic carbon and plant organic carbon in Fodder Maize (*Zea mays L.*) crop field in North Eastern and Western Zones of Tamil Nadu, India during summer season of 2012. For this study, in Western zone two districts viz., Coimbatore and Erode districts and in North Eastern Zone Tiruvannamalai and Vellore districts were selected for the field experiments. From the selected district, two villages were randomly selected (2 village/ district) for field experiments totaling to eight experimental sites for the study. Green fodder yield for T1 (Recommended dose of NPK) and T2 (Recommended dose of organic and inorganic fertilizer) on 60th day ranged between 36.15 to 39.07 t/ha and 36.92 to 40.23 t/ha for all villages. On the other hand, Dry Matter Yield for T1 and T2 on 60th day varied between 6.37 to 6.91 t/ha and 6.51 to 7.09 t/ha for all villages. Carbon Assimilation Potential for T1, T2 on 60th day varied between 3.17 to 3.82 t/ha and 3.32 to 3.99 t/ha for all villages. A positive correlation ($P<0.01$) existed between soil and plant organic carbon in Fodder Maize for both treatments (T1 and T2) during the study period. This study recommended the use of farmyard manure along with inorganic fertilizer as the best option for increased biomass yield which also had positive effect on carbon sequestration potential

Key Words: Green fodder yield, Dry matter yield, Farm yard manure, Fodder Maize,

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Inorganic fertilizer

INTRODUCTION

In India, modern agriculture based on chemicals is not sustainable because of problems associated with loss of soil productivity. Excessive soil erosion, plant nutrient losses, surface and ground water pollution as a result of pesticides and fertilizers are the factors that are responsible for loss of soil productivity. Intensive agriculture has also a negative effect on the soil environment over the past decades. Chemical fertilizers play a crucial role to meet the nutrient requirement of the crop, persistent nutrient depletion poses a greater threat to sustainable agriculture. Nowadays, consumer prefers organically grown produce as they are free of toxic residues and are grown with a concern for environment. Therefore, there is an urgent need to reduce the usage of chemical fertilizers and in turn increase the usage of organic manure. Use of organic manures alone or in combination with chemical fertilizers, helps in improving physico-chemical properties of the soil and improves the efficient utilization of applied fertilizers and results in higher fodder yield and quality. Judicious use of combinations of organic and inorganic resources is a feasible approach to overcome soil fertility constraints (Abedi *et al*., 2010). Combined organic and inorganic fertilization could enhance carbon storage in soils and reduce emission from N fertilizer use, while contributing to high productivity in agriculture (Pan *et al*., 2009). Sustaining soil health through inclusion of manure in the fertilization schedule is important since it can improve the organic carbon status and available N, P, K and S in soil (Tiwari *et al*., 2002). To improve soil physical properties, addition of various organic materials could be undertaken and combined use of NPK and FYM increases soil organic matter compared to application of NPK through inorganic fertilizers (Bhattacharya *et al*., 2008). Organic manures *viz*., farm yard manure, vermicompost, poultry manure and oilcakes help in the improvement of soil structure, aeration and water holding capacity of soil. Further, it stimulates the activity of microorganisms that makes the plant to get the macro and micro-nutrients through enhanced biological processes, increase nutrient solubility, alter soil salinity, sodicity and pH (Alabadan *et al*., 2009). Hence the present study was undertaken to determine the effect of inorganic fertilizer and combined effect of inorganic fertilizer with organic fertilizer (farm yard manure) on biomass yield, carbon assimilation potential and correlation coefficient between soil and plant organic carbon in Fodder Maize *(Zea mays* L.*)* in two agro climatic zones of Tamil Nadu.

MATERIALS AND METHODS

The field experiment was carried out using the Annual fodder crop, Fodder Maize (*Zea mays* L.) in two agro climatic zones of Tamil Nadu, India viz., Western and North Eastern zone during the summer season of 2012. In each zone two districts viz., Coimbatore and Erode districts (Western Zone) and Tiruvannamalai and Vellore districts (North Eastern zone) were selected. From each district, two villages were randomly selected, totaling to eight experimental sites for the study. In Coimbatore and Erode district the experimental sites were located at

Kondaiyampalayam (V1), Idigarai (V2), Velankattuvalasu (V3) and Velliyampalayam (V4). In Tiruvannamalai and Vellore district, the selected experimental sites were located at Vannankulam (V5), Kolathur village (V6), Saduperi (V7) and Thirumani (V8).

In all the selected sites the land was ploughed twice by a tractor with chisel ploughing followed by harrowing. The fields were brought to fine tilth, leveled with a wooden plank and laid out in to the proper plot size (6 x 4 m).The experiment was laid out with six replications per treatment in all the study fields. Fodder maize was planted at 60 x 30 cm intervals on either side of the ridges. The experiment consisted of two treatments viz., Treatment 1 (T1) which was control with recommended dose of NPK fertilizers (60 N, 40 P_2O_5 and 20 K_2O kg/ha) alone and Treatment 2 (T2) which included Farmyard Manure (Organic – Recommended dose - 12.5 t/ha) along with NPK fertilizer (inorganic – Recommended dose). The fertilizers were applied in the form of urea (N), Di-ammonium Phosphate (P_2O_5) and Muriate of Potash (K_2O). In all, 50 per cent of nitrogen and entire dose of P_2O_5 and K_2O were applied at the time of sowing and remaining 50 per cent of nitrogen was top dressed in the form of urea at 30 days after sowing (DAS). All the cultural practices were followed as per the recommended package of practices for the Fodder Maize crop. The necessary after care operations such as hand weeding were done as per the requirement. The plant protection measures have been adopted to control the pest and disease. Irrigation was carried out immediately after sowing (0^{th} day), on 3^{rd} day and there after once in 7 days. Green fodder yield was recorded from each net plot in one square meter area and expressed in tonnes/ha. For dry matter determination, aluminium containers were oven dried and weighed using electric balance. Ten grams of plant sample was weighed in each container and placed in an oven at 105 °C till constant weight was attained using the following formula.

$$\text{Dry Matter (\%)} = \frac{\text{wt. of oven dry sample}}{\text{wt. of sample before drying}} \times 100$$

$$\text{Dry matter yield (t/ha)} = \frac{\text{Fresh fodder yield} \times \text{Dry Matter (\%)}}{100}$$

The carbon sequestration (assimilation) by the plant was calculated using the following formula (Negi *et al*., 2003).

Carbon sequestered (Assimilation) = Biomass x Carbon (%)

Statistical analysis

The data collected were subjected to‘t’ test to find out the significant difference between treatments for all villages. In addition, One-Way ANOVA was performed using SPSS 13.0 to evaluate the significant difference between districts and zones. Also interpretation of data was done as per the procedure described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Green Fodder Yield in Fodder Maize

The Mean values of Green Fodder Yield (GFY) for Fodder Maize in Western and North Eastern zone of Tamil Nadu are presented in Table 1. Green fodder yield for T1 and T2 in 60th day ranged between 36.15 to 39.07 t/ha and 36.92 to 40.23 t/ha for all villages. Statistical analyses revealed highly significant (P<0.01) difference in fodder yield between treatments for the villages, V1, V2, V4 and significant (P<0.05) difference for other villages on 60th day of the trial period. The green fodder yield increase was due to the result of higher plant height, stem diameter and more dry matter production per plant. This was due to the regulatory role of nitrogen in production of amino acids and plant hormones responsible for cell division and enlargement and higher nitrogen facilitated optimum development of photosynthetic apparatus which captured the incident light more efficiently (Tariq *et al*., 2011). It could be observed from Table 1 that T2 values pertaining to green fodder yield were significantly (P < 0.05 or 0.01) higher than T1 at harvest stage (60th day). This could be due to the benefits of organic matter providing N, P, and K supply which resulted in improvement of microbial activity, better supply of macro and micro nutrients such as S, Zn, Cu and B which were not supplied by inorganic fertilizers and due to the lower losses of nutrients from the soil (Bhattacharya *et al*., 2008) . Moreover, farmyard manure with inorganic fertilizers not only increased the availability of nutrients and improved the soil fertility, but also enhanced fodder production significantly (Ahmad *et al*., 2011). Farmyard manure contained readily metabolizable carbon and N which increased the root biomass and root exudates and contributed to its biomass increase (Liu *et al*., 2010). Moreover, the beneficial effect of farm yard manure on yield might be due to increased organic matter present that has improved the soil structure conditions which encouraged the plant for good root development by improving the aeration of the soil. This was in agreement with the findings of Ouda and Mahadeen (2008) and Salam and Salem (2012). Moreover farm yard manure provided abounding organic matter for the growth of microorganisms which favored increased yield (Gong *et al*., 2009).

Dry Matter Yield in Fodder Maize

The Mean values of Dry matter yield (DMY) for Fodder Maize in Western and North Eastern zone of Tamil Nadu are presented in Table 2. Dry Matter Yield for T1 and T2 on 60th day ranged between 6.37 to 6.91 t/ha and 6.51 to 7.09 t/ha for all villages. Statistical analyses revealed highly significant (P<0.01) difference between treatments in DMY for Fodder Maize in the villages, V1, V2, V4 and significant (P<0.05) difference for other villages on 60th day of the trial period. The Dry matter yield was associated with the green fodder yield which in turn depends on fodder production. This was in concurrence with the findings of Ali *et al*. (2012). It could be observed from the results that T2 values were significantly (P < 0.05 or 0.01) higher than T1 at harvest stage (60th day). This might be due to the incorporation of farm yard manure which provided essential nutrients for growth of plant which significantly enhanced the fodder production and in turn on the dry

matter yield. This was in agreement with the findings of Sharma *et al.* (2012).

Carbon Assimilation Potential in Fodder Maize

The Mean values of Carbon Assimilation Potential (CAP) for Fodder Maize in Western and North Eastern zone of Tamil Nadu are presented in Table 3. CAP in Fodder Maize for T1 and T2 on 60th day ranged between 3.17 to 3.82 t/ha and 3.32 to 3.99 respectively for all villages. Statistical analyses revealed highly significant ($P<0.01$) difference between treatments in CAP for all the villages on 60th day of the trial period. The carbon assimilation potential depends mainly on the plant organic carbon as well as dry matter yield. With the increase of dry matter yield and plant organic carbon, the carbon assimilation potential of Fodder Maize increased. The results were in accordance with the findings of Montagnini and Nair (2004) and Yadava (2010). In general, fertilization stimulates biomass production and enhances carbon accumulation. This was in agreement with the findings of Schuman *et al.* (2002). Montagu *et al.* (2005) reported that biomass was an important indicator in carbon sequestration. Ground biomass of plants definitely has greater influence on the carbon sequestration potential in energetic crops (Walker *et al*., 2008). As far as villages are concerned, it could be observed that on 60th day, the carbon assimilation potential in Fodder Maize was significantly higher in V3 followed by V4, V2, V1, V6, V5, V8 and V7 in descending order. This might be due to significant increase in green fodder yield observed in V3 than V4, V2, V1, V6, V5, V8 and V7. This was in agreement with the findings of Ahmad *et al.* (2011) who stated that higher SOC content and combination of farm yard manure with inorganic fertilizers increased the availability of nutrients in soil resulting in higher fodder yield and enhanced carbon assimilation potential.

Correlation Coefficient

The correlation coefficient between Soil Organic Carbon and Plant Organic Carbon for Fodder Maize in Western zone and North Eastern zone of Tamil Nadu are presented in Table 4. The results revealed significant ($P < 0.01$) positive correlation between soil and plant organic carbon in Fodder Maize for both treatments (T1 and T2) during the experimental period. This might be due to plant growth which absorbed carbon-dioxide from the atmosphere and in turn stored in leaves, stems and root biomass (Tariq *et al.,* 2011). This was in agreement with the findings of Ingram and Fernandes (2001) who stated that abundant carbon accumulation was observed during plant harvest and root biomass acted as a sink in increasing soil organic carbon. Hence, with increased plant organic carbon there would be enhanced accumulation of soil organic carbon which was positively correlated.

It is concluded from the results that farmyard manure along with inorganic fertilizer resulted in significantly higher green fodder yield as well as dry matter yield of the fodder crop than individual. This increased green fodder yield resulted in higher carbon assimilation potential of the fodder crops which in turn could increase the soil fertility and productivity. Thus this study recommended the use of farmyard manure along with inorganic fertilizer as the best option for increased biomass yield

which also had positive effect on carbon sequestration potential.

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Table – 1. Green Fodder Yield (t/ha) in Fodder Maize (60th day) of Western and North Eastern zone of Tamil Nadu

Zone	District	Villages	Green Fodder Yield (t/ha)		
			T1	T2	t value
			Mean ± S.E	Mean ± S.E	
Western Zone	Coimbatore	Kondaiyampalayam (V1)	37.27 ± 0.12^{cd}	38.18 ± 0.17^{cd}	4.40**
		Idigarai (V2)	37.70 ± 0.13^{de}	38.82 ± 0.32^{de}	3.27**
	Erode	Velankattuvalasu (V3)	39.07 ± 0.26^{f}	40.23 ± 0.34^{f}	2.71*
		Velliyampalayam (V4)	38.08 ± 0.21^{e}	39.42 ± 0.31^{e}	3.59**
North Eastern Zone	Tiruvannamalai	Vannankulam (V5)	36.65 ± 0.20^{ab}	37.38 ± 0.17^{ab}	2.76*
		Kolathur (V6)	36.95 ± 0.21^{bc}	37.77 ± 0.19^{bc}	2.86*
	Vellore	Saduperi (V7)	36.15 ± 0.19^{a}	36.92 ± 0.17^{a}	2.88*
		Thirumani (V8)	36.47 ± 0.26^{ab}	37.38 ± 0.22^{ab}	2.67*
F value			21.96**	21.37**	

T1 (Recommended dose of NPK) and T2 (Recommended dose of organic and inorganic fertilizer)

Means bearing different superscripts between columns (T1 and T2) do not differ significantly

* - Significant (P<0.05) ** - Highly Significant (P<0.01)

Table – 2. Dry Matter Yield (t/ha) in Fodder Maize (60th day) of Western and North Eastern zone of Tamil Nadu

Zone	District	Villages	Dry Matter Yield (t/ha)		
			T1	T2	t value
			Mean ± S.E	Mean ± S.E	
Western Zone	Coimbatore	Kondaiyampalayam (V1)	6.58 ± 0.02^{cd}	6.73 ± 0.03^{c}	4.09**
		Idigarai (V2)	6.64 ± 0.02^{de}	6.85 ± 0.05^{d}	3.58**
	Erode	Velankattuvalasu (V3)	6.91 ± 0.05^{f}	7.09 ± 0.06^{e}	2.34*
		Velliyampalayam (V4)	6.70 ± 0.04^{e}	6.96 ± 0.05^{de}	4.00**
North Eastern Zone	Tiruvannamalai	Vannankulam (V5)	6.45 ± 0.03^{ab}	6.59 ± 0.03^{ab}	2.91*
		Kolathur (V6)	6.52 ± 0.04^{bc}	6.67 ± 0.03^{bc}	3.01*
	Vellore	Saduperi (V7)	6.37 ± 0.03^{a}	6.51 ± 0.02^{a}	2.95*
		Thirumani (V8)	6.44 ± 0.05^{ab}	6.61 ± 0.04^{abc}	2.79*
F value			22.68**	20.87**	

T1 (Recommended dose of NPK) and T2 (Recommended dose of organic and inorganic fertilizer)

Means bearing different superscripts between columns (T1 and T2) do not differ significantly

* - Significant (P<0.05) ** - Highly Significant (P<0.01)

Table – 3. Carbon Assimilation Potential (t/ha) in Fodder Maize (60th day) of Western and North Eastern zone of Tamil Nadu

Zone	District	Villages	Carbon Assimilation Potential (t/ha)		
			T1	T2	t value
			Mean ± S.E	Mean ± S.E	
Western Zone	Coimbatore	Kondaiyampalayam (V1)	3.47 ± 0.01^{de}	3.63 ± 0.03^{d}	5.73**
		Idigarai (V2)	3.53 ± 0.02^{e}	3.74 ± 0.04^{e}	4.81**
	Erode	Velankattuvalasu (V3)	3.82 ± 0.03^{g}	3.99 ± 0.04^{g}	3.49**
		Velliyampalayam (V4)	3.64 ± 0.03^{f}	3.86 ± 0.03^{f}	5.51**
North Eastern Zone	Tiruvannamalai	Vannankulam (V5)	3.35 ± 0.02^{c}	3.50 ± 0.02^{bc}	5.11**
		Kolathur (V6)	3.40 ± 0.02^{cd}	3.57 ± 0.03^{cd}	4.14**
	Vellore	Saduperi (V7)	3.17 ± 0.02^{a}	3.32 ± 0.02^{a}	4.98**
		Thirumani (V8)	3.27 ± 0.03^{b}	3.43 ± 0.03^{b}	3.31**
F value			68.02**	53.62**	

T1 (Recommended dose of NPK) and T2 (Recommended dose of organic and inorganic fertilizer)

Means bearing different superscripts between columns (T1 and T2) do not differ significantly

* - Significant (P<0.05) ** - Highly Significant (P<0.01)

Table – 4. Correlation Coefficient between Soil Organic Carbon and Plant Organic Carbon for Fodder Maize in Western and North Eastern zone of Tamil Nadu

Soil Vs fodder	Correlation Coefficient	
Treatments	Fodder Maize	
	30 days	60 days
T1	0.76**	0.73**
T2	0.78**	0.76**

** - Highly Significant (P<0.01)