Forage Res., **46** (2) : pp. 176-181 (2020) **http://forageresearch.in**

FARM YARD MANURE EFFECTS ON PLANT ORGANIC CARBON, BIOMASS YIELD AND CARBON ASSIMILATION POTENTIAL IN FODDER COWPEA (*VIGNA UNGUICULATA*)

B. RAJESH KUMAR*

Tamil Nadu Veterinary and Animal Sciences University
Veterinary University Training and Research Centre,
District Collectorate Campus Sathuvachari, Vellore-623009, Tamil Nadu
(e-mail : drrajeshvet2008@gmail.com)

(Received : 12 August 2020; Accepted : 10 September 2020)

SUMMARY

A field experiment was conducted to study the effect of inorganic fertilizer and the combined effect of farmyard manure (organic) with inorganic fertilizer on the Plant Organic Carbon, Green Fodder Yield (GFY), Dry Matter Yield (DMY) and Carbon Assimilation Potential (CAP) in Fodder cowpea (*Vigna Unguiculata*) crop field in North Eastern and Western Zones of Tamil Nadu, India during summer season of 2012. For the study, in Western zone two districts viz., Coimbatore and Erode and in North Eastern Zone Tiruvannamalai and Vellore districts were selected for the field experiments. From the selected district, two villages were selected (2 village/ district) for field experiments totaling to eight experimental sites for the study. The Plant organic carbon on 60th day ranged from 42.52 to 44.53% for T_1 (RDF) and 43.08 to 44.96% for T_2 (RD of organic and inorganic fertilizer) for all the villages. The GFY for T_1 and T_2 on 60th day ranged between 16.72 to 18.31 t/ha and 17.04 to 18.99 t/ha, respectively in all villages. On the other hand, Dry Matter Yield for T_1 and T_2 on 60th day varied between 2.44 to 2.68 t/ha and 2.49 to 2.71 t/ha for all villages. Carbon Assimilation Potential for T_1, T_2 on 60th day varied between 1.04 to 1.19 t/ha and 1.07 to 1.25 t/ha for the villages under study. This study recommended the use of farmyard manure along with inorganic fertilizer as the best option for increased plant organic carbon, biomass yield which also had positive effect on carbon assimilation potential.

Key Words : Green fodder, dry matter, FYM, fodder cowpea, inorganic fertilizer, carbon assimilation potential

Legumes are the most important forage plants that substantially improve the feed available for livestock providing the essential protein for animals, improving soil fertility, food crop production and household nutrition. Cowpea is an important legume grown in the semiarid tropic and sub-tropic regions. It has ability to tolerate drought and fix atmospheric nitrogen which allows it to grow and improve poor soils (Nguyen *et al*., 2019). It is used at all stages of the crop for both human and animal consumption. Besides being used as pulse in form of dry seed, cowpea's immature pod and green leaf and growing twig can be utilized as vegetable (Nguyen *et al*., 2017). For its high protein value. It is consumed as dry seeds, green pods or leaves. Cowpea fixes atmospheric nitrogen up to 240 kg/ha and leaves about 60 to 70 kg nitrogen for succeeding crops. Cowpea is a valuable component of farming systems in many areas because of its ability to restore soil fertility for succeeding cereal crops grown in rotation.

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 have 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). Organic manures *viz*., farm yard manure, vermicompost and poultry manure 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 plant organic carbon, biomass yield and carbon assimilation potential in Fodder cowpea.

MATERIALS AND METHODS

The field experiment was carried out using the Annual fodder crop, Fodder Cowpea (*Vigna unguiculata)* in 2 agroclimatic zones of Tamil Nadu. 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 and in each district, two villages were selected for field experiments totaling to eight experimental sites (Table 1) for the study. Composite soil samples were collected at a depth of 0-15 cm in all the experimental villages prior to the study and analysed for the physico chemical properties. The land was ploughed twice by a tractor with chisel ploughing followed by harrowing and the field was brought to fine tilth, leveled with a wooden plank and laid out in to proper plot size (6 m × 4 m). The experiment was laid out with six replications per treatment in all the study fields. Fodder cowpea 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 is control with recommended dose of NPK fertilizers (25 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). All the cultural practices were followed as per the recommended package of practices for Fodder Cowpea crop (Crop Production Guide, 2012).

Fodder samples were collected at random just above the ground level at 30th day and on 60th day. The samples were shade dried and kept in oven at 60-70°C till constant weight was obtained. Finally the dried samples were ground to fine powder and subjected for chemical analysis of organic carbon by using Analytikjena multi N/C 2100S carbon analyzer. The equipment is crafted with a focus radiation NDIR detector and can with stand furnace temperature of 950°C. Also this equipment uses oxygen as supportive gas for estimation of Plant organic carbon.

Green fodder yield was recorded from each net plot in one square meter area and expressed in t/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.

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

TABLE 1
Physicochemical properties of the soil at experimental sites

Zone	District	Villages	Soil Properties						
			pH	Soil type	Electrical conductivity (EC)	Organic carbon (%)	Available Nitrogen (kg/ha)	Available Phosphorus (kg/ha)	Available Potassium (kg/ha)
Western	Coimbatore	Kondaiyampalayam (V1)	7.1	Black	0.57	0.28	228.08	33.35	283.31
		Idigarai (V2)	7.3	Black	0.56	0.29	225.34	33.84	287.76
	Erode	Velankattuvalasu (V3)	7.5	Red loamy	0.60	0.34	232.20	35.82	297.88
		Velliyampalayam (V4)	7.4	Black	0.58	0.32	227.68	34.83	293.68
North Eastern	Tiruvannamalai	Vannankulam (V5)	7.0	Dark brown	0.58	0.25	226.55	31.62	276.89
		Kolathur (V6)	7.1	Red sandy	0.56	0.27	222.70	32.36	285.04
	Vellore	Saduperi (V7)	6.9	Red sandy	0.54	0.23	225.83	33.10	263.06
		Thirumani (V8)	6.8	Dark brown	0.53	0.24	220.37	32.60	271.21

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

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

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

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

The Mean values of Plant Organic Carbon (OC) in Fodder Cowpea for both the zones are presented in Table 2. It could be observed from the results that the plant organic carbon gradually increased from 30th day to 60th day. On 60th day the plant OC content for T1 varied from 42.52 to 44.53 per cent and 43.08 to 44.96 per cent for T2. Significant ($P< 0.05$ or 0.01) higher plant organic carbon content was observed for all the villages for T2 than T1. The values of plant organic carbon in Fodder Cowpea observed in the present study was in concurrence with the values reported by Etana *et al.* (2013) who had evaluated different cowpea accessions and found that the plant organic carbon content varied from 43.71 per cent to 45.83 per cent at harvest stage of the crop. In yet another study, Kasangi *et al.* (2010) analysed the proximate composition of cowpea leaves and found that plant organic carbon content recorded values from 50.41 per cent to 52.25 per cent.

The plant OC of Fodder Cowpea increased towards 60th day compared to initial stage of 30th day. This was in agreement with the findings of Suksombat and Buakeeree, (2006) who conducted an experiment to study the effect of different cutting intervals on the chemical composition of leguminous fodder Hedge Lucerne and found that the organic carbon content increased from 53.79 % (30 days) to 54.5 % (50 days). Further they stated that the organic carbon of the fodder increased as a result of maturation of plant growth as a result of utilization of plant nutrients. During initial stages of the growth of Fodder Cowpea there would be less sequestration of carbon-dioxide as the biomass of the plant at 30th day would be low. With the advancement of plant growth sequestration of carbon would be more since the biomass at the end of the harvest stage increased. Incorporation of farm yard manure along with recommended dose of NPK fertilizers in T2 showed significantly higher organic carbon content than T1 during the trial period. The probable reason could be due to increased soil respiration with farm yard manure application due to higher organic matter levels and also due to stronger effect on dehydrogenase activity which helped in enhancement of soil organic carbon and thereon to the Fodder Cowpea (Enke Liu *et al.*, 2010).

Green Fodder yield

The Mean values of Green Fodder Yield (GFY) for Fodder Cowpea are presented in Table 3.

TABLE 2

Mean values of Plant Organic Carbon (in %) in Fodder Cowpea in Western and North Eastern zone of Tamil Nadu

Zone	District	Villages	30th day			60th day		
			T1	T2	t value	T1	T2	t value
Western	Coimbatore	V1	43.06^{bc}	43.46^{bc}	2.89*	43.66^{cd}	44.19^{c}	2.53*
		V2	43.52^{cd}	43.93^{d}	3.85**	43.90^{d}	44.53^{d}	3.67**
	Erode	V3	44.01^{d}	44.50^{e}	2.34*	44.53^{e}	44.96^{e}	3.07*
		V4	43.58^{cd}	43.97^{d}	3.45**	44.04^{d}	44.61^{d}	3.04*
North Eastern	Tiruvannamalai	V5	42.66^{b}	43.23^{bc}	2.75*	43.38^{bc}	44.00^{c}	3.00*
		V6	43.04^{bc}	43.32^{c}	3.73**	43.62^{cd}	44.04^{c}	3.03*
	Vellore	V7	41.33^{a}	42.77^{a}	2.88*	42.52^{a}	43.08^{a}	3.26**
		V8	42.55^{b}	42.89^{ab}	2.30*	43.03^{b}	43.48^{b}	2.23*
		F value	18.08**	23.92**		19.88**	28.31**	

Means bearing same superscripts within columns do not differ significantly.

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

Green fodder yield for T1 and T2 on 60th day ranged from 16.72 t/ha to 18.31 t/ha and from 17.04 t/ha to 18.99 t/ha. The green fodder yield values recorded were within the range values reported by Etana *et al.* (2013) on evaluation of different cowpea accessions for fodder production with the green fodder yield ranging between 11.10 t/ha to 29.09 t/ha. Nitrogen is a vitally important plant nutrient involved in protein and enzyme synthesis. Also the availability of soil nitrogen and other macro and micronutrients could have enhanced meristematic growth and resulted in higher Fodder Cowpea yield. This was in agreement with the findings of Islam *et al.* (2010). Moreover among the aerial plant parts, the leaves were more responsive for additional nitrogen supply than stems and also nitrogen influenced the total biomass production of Fodder Cowpea (Tariq *et al.* 2011). Application of potassium fertilizer along with FYM increased the fodder yield. Also the positive response to K and FYM was a function of increased water retention, field capacity, available water along with other properties of the sandy soil conducive to high fertility of the crop (Salam and Salem, 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 could be due to the benefits of organic matter from farm yard manure which provided N, P, and K supply resulting 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 lower losses of nutrients from the soil (Bhattacharya *et al.*, 2008). Also it could be due to availability of N in proper proportion and improvement in soil structure by FYM. Moreover, the N was made available at proper time which was required for better growth and development of plants and improvement in moisture retention and soil structure by FYM. Also the readily metabolizable carbon and N in FYM would have increased the root biomass and root exudates which played a vital role in contributing to its biomass increase (Enke liu *et al.*, 2010).

Dry Matter Yield

The Mean values of Dry Matter Yield (DMY) are presented in Table 3. Dry matter yield for T1 and T2 on 60th day ranged from 2.44 t/ha to 2.68 t/ha and from 2.49 t/ha to 2.78 t/ha. The Dry matter yield was associated with the green fodder yield which in turn depends on fodder production. This was in accordance 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 could 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 (Sharma *et al.*, 2012). Similarly, Salam and Salem (2012) studied the interaction between potassium and organic manure application on growth of cowpea and observed that the dry matter yield increased from 13.5 mg/ha to 21.1

TABLE 3

Mean Values of Biomass (t/ha) and Carbon Assimilation Potential in Fodder Cowpea (60th day) of Western and North Eastern zone of Tamil Nadu

Zone	District	Villages	Biomass (t/ha)						Carbon Assimilation Potential (t/ha)		
			Green Fodder Yield (t/ha)			Dry Matter Yield (t/ha)					
			T1	T2	t value	T1	T2	t value	T1	T2	t value
Western	Coimbatore	V1	17.58[de]	18.07[cd]	2.70*	2.57[de]	2.64[cd]	2.77*	1.12[de]	1.17[cde]	4.66**
		V2	17.80[ef]	18.36[de]	3.11*	2.61[ef]	2.68[de]	2.90*	1.14[ef]	1.20[e]	3.78**
	Erode	V3	18.31[g]	18.99[f]	2.46*	2.68[g]	2.78[f]	2.36*	1.19[g]	1.25[f]	3.04*
		V4	18.11[fg]	18.73[ef]	3.27**	2.65[fg]	2.74[ef]	3.41**	1.17[f]	1.22[f]	3.66**
North Eastern	Tiruvannamalai	V5	17.20[bc]	17.66[bc]	2.43*	2.52[bc]	2.59[bc]	2.49*	1.09[c]	1.14[c]	3.49**
		V6	17.41[cd]	17.92[cd]	2.51*	2.55[cd]	2.63[cd]	2.63*	1.11[cd]	1.16[cd]	3.42**
	Vellore	V7	16.72[a]	17.04[a]	3.20**	2.44[a]	2.49[a]	3.55**	1.04[a]	1.07[a]	5.19**
		V8	16.94[ab]	17.31[ab]	2.79*	2.48[ab]	2.54[ab]	2.97*	1.07[b]	1.10[b]	4.12**
F value			21.15**	21.59**		22.57**	21.77**		40.53**	36.31**	

Means bearing same superscripts within columns do not differ significantly.

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

mg/ha and concluded that the potassium fertilizer along with FYM increased the dry matter yield.

Carbon Assimilation Potential

The Mean values of Carbon Assimilation Potential (CAP) for Fodder Cowpea are presented in Table 3. CAP for T1 and T2 on 60th day ranged from 1.04 t/ha to 1.19 t/ha and 1.07 t/ha to 1.25 t/ha. It is evident that significantly ($P < 0.05$ or 0.01) higher carbon assimilation potential (CAP) is observed for T2 than T1 in all the villages. 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 OC, the carbon assimilation potential of Fodder Cowpea increased. Similar results attributing higher CAP to higher biomass and carbon stock was also reported by Yadava (2010). Also for the production of organic matter, crops absorb carbon-dioxide from the atmosphere. The carbon-dioxide from the atmosphere gets absorbed by plants as a result of photosynthetic activity and also translocated to roots. Farm yard manure along with recommended dose of inorganic fertilizer increased the dry matter yield of Fodder Cowpea due to the synergistic effect of manure. This was in agreement with the findings of Salam and Salem (2012) who studied the interaction between potassium and organic manure application on growth of cowpea and observed that the dry matter yield increased from 13.5 mg/ha to 21.1 mg/ha, concluding that the increased application of potassium fertilizer along with FYM increased the dry matter yield.

Biomass was an important indicator in carbon sequestration. Ground biomass of plants definitely had greater influence on the carbon sequestration potential in energetic crops.

As far as villages are concerned, it could be observed that on 60th day the CAP in Fodder Cowpea 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 yield and organic matter content observed in V3 than V4, V2, V1, V6, V5, V8 and V7. This was in agreement with the findings of Yoganathan *et al.* (2013) who studied the integrated use of animal manure and inorganic fertilizer on growth and yield of cowpea and found that highest fodder yield was obtained with integrated use of animal manure along with inorganic fertilizer which increased the availability of nutrients in soil resulting in higher fodder yield and enhanced carbon assimilation potential.

CONCLUSION

From the findings of the experiment, it could be concluded that RDF+12.5 t/ha farm yard manure (FYM) can be used as a viable option for increased plant organic carbon, biomass yield in fodder Cowpea which definitely have an impact on carbon assimilation potential.

REFERENCES

Abedi, T., A. Alemzadeh and S. A. Kazemelni, 2010 : Effect of organic and inorganic fertilizers on grain yield and protein banding pattern of wheat. *Aust. J. Crop. Sci*., **4**: 384-389.

Alabadan, B. A., P.A.Adeoye and E.A.Folorunso, 2009 : Effects of different poultry wastes on physical, chemical and biological properties of soil. *Caspian J. Environ. Sci*., **7** : 31-35.

Ali, S., M. Sahiba, Azim Malik, Fayyaz-ul-Hassand, and M. Ansar, 2012 : Growth of rainfed fodder maize under different levels of nitrogen and phosphorus. *Pak. J. Agri. Res.*, **25** : 196-205.

Bhattacharya, R., S. Kundu, V. Prakash and H. S. Gupta, 2008 : Sustainability under combined application of mineral and organic fertilizers in a rainfed soybean-wheat system of the Indian Himalayas. *Eur. J. Agron*., **28** : 33-46.

Crop Production Guide, 2012 : Tamil Nadu Agricultural University, Pp 300 - 301.

Enke liu., Y. Changrong, M. Xurong, H. Wenqing, D. Linping, L. Qin, L. Shuang and F. Tinglu, 2010 : Long term effect of chemical fertilizer, straw and manure on soil chemical and biological properties in north-west China. *Geoderma*, **158** : 173-180.

Etana, A., E. Tadesse, A. Mengistu and A. Hassen, 2013 : Advanced evaluation of cowpea (*Vigna unguiculata*) accessions for fodder production in the central rift valley of Ethiopia. *J. Agri. Ext. Rural Dev.*, **5** : 55-61.

Gomez, K. A. and A. A. Gomez, 1984 : Statistical Procedure for Agricultural Research - Hand Book. John Wiley & Sons, New York.

Islam, M. R., S. M. E. Rahman, M. M. Rahman, D. H. Oh and C. S. Ra, 2010 : The effects of biogas slurry on the production and quality of maize fodder. *Turk. J. Agric. For*., **34** : 91-99.

Kasangi, D. M., A. A. Shalo, P. L. Shalo and S. K. Mbugua, 2010 : Effect of spontaneous fermentation of cowpea leaves (*Vigna unguiculata*) on proximate composition, mineral content, chlorophyll content and beta-carotene content. *Inter. Food Res. J.*, **17** : 721-732.

Negi, J. D. S., R. K. Manhas and P. S. Chauhan. 2003 : Carbon allocation in different components of some tree species of India. A new approach for carbon estimation. *Current Sci*., **85** : 101-104.

Nguyen Ngoc Vu, R. K. Arya, R. Panchta and Jayanti Tokas, 2017 : Studies on Genetic divergence in cowpea (*Vigna unguiculata*) by using D^2 statistics under semi-arid conditions. *Forage Res*., **43** : 197-201.

Nguyen Ngoc Vu, R. K. Arya and R. Panchta, 2019 : Studies on genetic parameters, correlation and path coefficient analysis in cowpea. *Range Mgmt. & Agroforestry*, **40** : 49-58.

Pan, G., P. Zhou, Z. Li, S. Pete, Li, D. Qiu, X. Zhang, X. Xu, S. Shen and X. Chen, 2009 : Combined inorganic/organic fertilization enhances N efficiency and increased rice productivity through organic cabon accumulation in a rice paddy from the Tai Lake region, China. *Agri. Ecosys. Environ*., **131** : 274-280.

Salam, M. A. A. and H. M. Salem. 2012 : Interaction between potassium and organic manure application on growth of cowpea (*Vigna unguiculata* L.) and soil properties in newly reclaimed sandy soil. *World J. Agri. Sci*., **8(2)**: 141-149.

Sharma, A., A. K. Sharma, R. K. Sharma, R. Bharat and P. K. Rai, 2012 : Effect of different levels of nitrogen, organic manure and planting time on yield and quality of Hybrid Napier. *Indian J. Anim. Nut*., **29** : 33-39.

Suksombat, W. and K. Buakeeree. 2006 : Effect of cutting interval and cutting height on yield and chemical composition of Hedge Lucerne (*Desmanthus virgatus*). *Asian-Aust. J. Anim.Sci.*, **19** : 31-34.

Tariq, M., M. Ayub, M. Elahi, A.H. Ahmad, M. N. Chaudhary and M. A. Nadeem, 2011 : Forage yield and some quality attributes of millet (*Pennisetum americannuam L.*) hybrid under various regimes of nitrogen fertilization and harvesting dates. *Afr. J. Agri. Res*., **6** : 3883-3890.

Yadava, A. K., 2010 : Biomass production and carbon sequestration in different agro-forestry systems in *Tarai* region of Central Himalaya. *Indian Forester*, **136** : 234-244.

Yoganathan, R., H. K. L. K. Gunasekera and R. Hariharan, 2013 : Integrated use of animal manure and inorganic fertilizer on growth and yield of vegetable cowpea (*Vigna uniquiculata*). *World Acad. Sci. Eng. Tech.*, **80** : 376-379.