Forage Res., **45** (4) : pp. 318-322 (2020) **http://forageresearch.in**

CONTINUOUS CULTIVATION OF FODDER MAIZE AND ITS IMPACT ON SOIL FERTILITY AND ECONOMICS IN WESTERN ZONE OF TAMIL NADU

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(Received : 4 January 2020; Accepted : 5 March 2020)

SUMMARY

A field experiment was conducted with an objective to assess the economics of continuous cultivation and supply of fodder maize and its impact on soil health. The trial was laid out with three kinds of cropping sequences *i.e* fodder maize three times with and without FYM. Available nutrient status in soil and crop nutrient uptake carried out after harvest in the cropping sequence showed the higher green fodder yield of 117 t/ha/yr with addition of FYM @ 25 t/ha than non-manured plots (98 t/ha/yr). In the interaction, three crops of fodder maize and one crop of fodder cowpea in the cropping sequence with FYM @ 25t/ha had produced maximum green fodder yield (134 t/ha/year) with higher net returns and BCR (1.80) over sole fodder maize. Soil analytical report revealed green manure included sequence registered higher soil quality parameters. Irrespective of cropping sequences of fodder maize, FYM applied plots @25 t/ha recorded higher nutrient status, organic carbon and microbial population. However, for sustainable soil health, three crops of fodder maize with inclusion of green manure (dhaincha) and FYM @25t/ ha showed better results in terms of increased nutrient status (17 % increase of OC and 13,16 and 8 % of N,P and K over initial status,) and soil microflora.

Key words : Fodder maize, cropping sequences, fodder yield, soil nutrients, economics

To feed the increasing livestock population continuous supply of green fodder is essential for balanced nutrition. Because of reduced biomass supply with progressive harvest with perennial forages, the green fodder supply through annual forages fetching important place. So farmers are choosing annual forages especially fodder maize and cultivating season after season due to its easy establishment, heavy biomass and heavy demand in the market. But continuous cultivation deteriorates soil health also. Though maize fodder has low protein content, it is relished by the animals due to being succulent and palatable. The maize fodder plays a vital role in increasing the productivity of the livestock and making this enterprise more profitable. The crop has an edge over cultivated fodder crops due to its adaptability and excellent fodder quality and usage in the form of silage. Hence, to continue the maize fodder cultivation without losing soil fertility, a legume crop can be cultivated in the continuous maize crop cultivation series. Since the nutrient turnover in soil plant system is considerably high under intensive cropping system, the deteriorating soil health could be recovered by including legume fodder to meet fodder demand as well as green manure to improve the soil quality. The information on continuous cultivation of maize on economics and its impact on soil health is lacking. The approach of integrating fodder maize with other crops is to get maximum economic yield without any deleterious effect on physico-chemical and biological properties of the soil. Even with balanced use of NPK fertilizer on long term basis, high yield level could not be maintained over the years because of deficiencies of secondary as well as micronutrients and deterioration in soil physical health. A use of organic with legume fodder should be opted for maximizing economic yield and to improve soil health.

MATERIALS AND METHODS

In order to work out the economics and soil health as influenced by the continuous cultivation of fodder maize, an field experiment was initiated at the Eastern Block farm of the Department of Farm Management,

TNAU, Coimbatore during the year 2016 -17. First year one cropping sequence has been completed (2017-18). The maize variety used in the study was African tall. The trial was laid out with 6 treatments of 5 cents each plot *i.e*. three kinds of cropping sequences tried with and without FYM *viz*. T1: Fodder maize- Fodder maize- Fodder maize- Fodder maize with FYM, T2: Fodder maize- Fodder maize- Fodder maize- Fodder maize without FYM, T3: Fodder maize- Fodder maize- Fodder maize- Green manure with FYM, T4: Fodder maize- Fodder maize- Fodder maize +Green manure without FYM,T5: Fodder maize- Fodder maize- Fodder cowpea- Fodder maize without FYM and T6: Fodder maize- Fodder maize- Fodder cowpea- Fodder maize without FYM. Before Initiation of the experiment, initial soil samples were collected and analyzed for nutrient status (N, P and K) and microbial load. Regular package of practices were followed throughout the crop period as per schedule while application of FYM was done as per treatments. Biometric observations on various growth and yield parameters of crops were recorded at regular intervals. The pH of the experimental soil was 8.05 with EC of 0.56 dS/m. Organic carbon content of soil was 0.58%. Soils were low in available nitrogen (240 kg/ha), medium in available phosphorus (21.5 kg/ha) and high in available potassium (358 kg/ha). Analysis of available nutrient status in soil and crop nutrient uptake was carried out after harvest of each crop in the cropping sequence. Also, analysis of microbial count of bacteria, fungi and actinomycetes was done in all the treatment plots during vegetative stage of the crops. As a confirmation trial, second cropping sequence was initiated during 2017-18 and completed during 2018-19 under irrigated condition. The details sowing and harvest details are furnished below.

Dates of sowing and harvest of crops in the cropping sequence

Crop	Sowing date	Harvest date
First crop sequence		
1st crop (fodder maize)	13.10.2016	05.01.2017
2nd crop (fodder maize)	07.02.2017	21.04.2017
3rd crop (fodder maize/ fodder cowpea)	14.06.2017	31.08.2017
4th crop (fodder maize/ green manure)	11.09.2017	29.11.2017
Second crop sequence		
1st crop (fodder maize)	11.01.2018	28.03.2018
2nd crop (fodder maize)	05.04.2018	18.06.2018
3rd crop (fodder maize/ fodder cowpea)	17.07.2018	16.10.2018
4th crop (fodder maize/ green manure)	14.11.2018	01.02.2019

RESULTS AND DISCUSSION

Green fodder yield

The data from Table 1 (first year result), 2 (second year result) and 3 (mean of two years) revealed that, FYM applied treatments recorded higher green fodder yield as compared to treatments without application of FYM in the first cropping sequence. During first year, the highest green fodder yield of 128400 kg/ha was recorded when fodder maize was cultivated during three seasons with inclusion of fodder cowpea along with FYM application @ 25 t/ha. (T3). The lowest green fodder yields were obtained in treatments with inclusion of green manure crop (incorporated *in-situ*) or without FYM application (83280 kg). Though lowest yield was recorded, soil quality was improved in the particular treatment. The effect of green manure incorporation in the respective treatments (T3 and T6) towards green fodder yield and soil fertility status was also observed with the crops raised during second cropping sequence. The confirmatory results were obtained. As a mean of two year results, highest green fodder yield of 133950 kg/ha/yr was observed with T3 *i.e*. fodder maize was cultivated during three seasons with inclusion of fodder cowpea along with FYM application @ 25 t/ha. The dry fodder yield also noticed with same trend of results (Table 4).

Fodder quality

The treatment T3 recorded higher crude protein content of 10.10 percent and the same cropping sequence recorded lower crude fibre content of 34.2 per cent .The higher crude protein content might be due to more availability of nitrogen, which ultimately

TABLE 1
Influence of treatments on green fodder yield (kg/ha) of fodder maize -I cropping sequence

Treatments	1st crop	2nd crop	3rd crop	4th crop	Total
With FYM @ 25 t/ha					
T1	35850	25250	32670	33100	126870
T2	36200	26200	33210	0	95610
T3	36850	25450	23600	42500	128400
Mean	36300	25633	29827	25200	116960
Without FYM					
T4	27750	19800	28020	29400	104970
T5	30150	21450	31680	0	83280
T6	29200	20350	18840	37800	106190
Mean	29033	20533	26180	22400	98147

TABLE 2
Influence of treatments on green fodder yield (kg/ha) of fodder maize -II cropping sequence

Treatments	1st crop	2nd crop	3rd crop	4th crop	Total
With FYM @ 25 t/ha					
T1	27500	25950	26750	31100	111300
T2	42000	30950	32600	0	105550
T3	38350	32650	35000	33500	139500
Mean	35950	29850	31450	21533	118783
Without FYM					
T4	20850	22500	25000	27400	95750
T5	37600	26950	28200	0	92750
T6	36400	26950	15000	29800	108150
Mean	31617	25467	22733	19067	98883

TABLE 3
Influence of treatments on green fodder yield (kg/ha) of fodder/ maize-Pooled mean

Treatments	I cropping sequence	II cropping sequence	Mean
With FYM @ 25 t/ha			
T1	126870	111300	119085
T2	95610	105550	100580
T3	128400	139500	133950
Mean	116960	118783	117872
Without FYM			
T4	104970	95750	100360
T5	83280	92750	88015
T6	106190	108150	107170
Mean	98147	98883	98515

led to more nitrogen uptake and nitrogen content accumulated in plants and extended benefit with congenial biochemical reactions at higher FYM levels as reported by Kamalakumari and Singaram (1996). Increase in protein content with increase in FYM levels was also reported by Nimjhe and Seth (1998) and Balyan *et al.* (2008).

Less nitrogen supply causes carbohydrates to deposit into the cells. Higher nitrogen application accelerates the protein formation from manufactured carbohydrates and also helps in reduced rate of lignifications thereby maintaining the fodder quality. Nitrogen application increased the protein synthesis and decreased pectin, cellulose and hemicellolose contents, which are major constituents of crude fibre (Tiwana *et al.*, 2003).

Nutrient uptake

The cropping sequences influence the nutrient uptake. Among the different treatments, T3 recorded

TABLE 4
Effect of intensive cultivation of fodder maize on mean dry fodder yield (kg/ha)

Treatments	I cropping sequence	II cropping sequence	Mean
With FYM @ 25 t/ha			
T1	25374	23373	24374
T2	19122	21110	20116
T3	25680	26505	26093
Mean	23392	23663	23528
Without FYM			
T4	20994	22023	21509
T5	16656	19478	18067
T6	21238	22246	21742
Mean	19629	21249	20439

TABLE 5
Effect of intensive cultivation of fodder maize on fodder quality (%)

Treatments	Crude protein (%)	Crude fibre
With FYM @ 25 t/ha		
T1	9.98	35.1
T2	9.86	35.2
T3	10.10	34.2
Mean	9.98	34.8
Without FYM		
T4	9.62	35.2
T5	9.50	35.9
T6	9.38	35.4
Mean	9.50	35.5

higher N, P and K uptake of 262,52 and 186 kg/ha respectively and the same cropping sequence recorded higher P and K nutrient uptake in without FYM also (Table 6). The extent of decrease was less when nutrient supply was made practically through inorganic sources in combination with organic sources as compared to chemical fertilizers alone (Kumar *et al.*, 2016).

Soil fertility

The Table 7 reveals that, the important soil quality parameter *i.e.* soil organic carbon got increased with the FYM application than without FYM application in all the three cropping sequences particularly with T2 (Fodder maize sequenced with green manure application with FYM (0.70%). Though GM sequenced crop recorded lower B/C ratio, but soil fertility was maintained with high SOC content. Bama (2014, 2017) reported a drastic improvement in the organic carbon status of the soil by the application of organic manures in the cumbu napier hybrid grass

TABLE 6
Effect of intensive cultivation of fodder maize on nutrient uptake (kg/ha/yr)

Treatments	N uptake	P uptake	K uptake
With FYM @ 25 t/ha			
T1	259	52	183
T2	195	39	138
T3	262	52	186
Mean	239	48	169
Without FYM			
T4	222	42	158
T5	180	36	127
T6	229	46	162
Mean	212	42	150

TABLE 7
Effect of intensive cultivation of fodder maize on soil health

Treatments	SOC (%)	Available N (kg/ha)	Available P (kg/ha)	Available K (kg/ha)
With FYM @ 25 t/ha				
T1	0.66	252	23.8	365
T2	0.70	272	24.8	388
T3	0.68	268	24.2	375
Mean	0.68	264	24.0	376
Without FYM				
T4	0.58	246	21.9	346
T5	0.62	264	21.8	377
T6	0.60	252	22.0	352
Mean	0.60	254	22.0	358

grown soil i.e higher organic carbon content of 1.28 per cent in the FYM applied on N equivalent basis than other organic sources over an initial carbon status of 0.71 % only. The increase in organic carbon attributed to direct addition of organic manure in the soil which stimulated the growth and activity of microorganisms and also due to better root growth resulting in the higher production of biomass, crop stubbles and residues. Soil organic carbon as influenced by cumbu Napier grown soil under different nutrient sources. The available nutrients, N, P and K increased with FYM applied treatment compared to without FYM particularly green manure included cropping sequence recorded higher nutrient status. Smith *et al.* (2000) reported that, application of manure to crop land enhanced the SOC pool than in pasture land. Majumder *et al.* (2008) observed the maximum amount of organic carbon in the recommended dose of fertiliser+ FYM treatment because of high biomass production.

Soil microbial population

The results of the present study revealed that the bacteria, fungi and actinobacteria were increased in the treatments imposed with FYM (T1, T2 and T3) compared to treatments without FYM (T4, T5 and T6) (Table 8).Further, Green manure sequenced crop recorded higher microbial population than other cropping sequences. This is in corroboration with the findings of that the amounts of soil organic C and soil microbial biomass C (SMBC) were significantly higher in the plots amended with organic materials, as compared to those of the conventional plots those received only inorganic fertilizers. Bama and Babu (2016) also reported that, organics application favourably improved the microbial activity in the fodder crops grown soils.

TABLE 8
Effect of intensive cultivation of fodder maize on soil microbial population.

Treatments	Bacteria (10^6 CFU)	Fungi (10^4 CFU)	Actinobacteria (10^3 CFU)
With FYM @ 25 t/ha			
T1	28.4	16.4	7.2
T2	32.8	17.8	8.6
T3	29.2	16.8	7.8
Mean	30.1	17.0	7.9
Without FYM			
T4	25.8	10.5	4.7
T5	27.5	12.5	5.5
T6	26.1	11.1	4.9
Mean	26.5	11.4	5.0

ECONOMICS

The data on economics of fodder maize cultivation during the first and second cropping sequence is presented in Table 9. The results showed that there exists slight variation in total cultivation cost among the treatments which was due to inclusion of input costs *viz*., FYM, seed cost of fodder maize, fodder cowpea and daincha crops, fertilizers and field preparation expenses. Among the treatments, higher gross return (Rs. 268600/ha), net return (Rs. 110512/ ha) and BCR (1.73) were recorded with fodder maize cultivation with fodder cowpea and FYM application (T3). Cultivation of fodder maize continuously with FYM application (T1) in the cropping sequence remained close to cultivation of fodder maize with one crop of fodder cowpea without FYM application T3) in terms of gross return, net return and BCR. Lower economic values were recorded with green manure applied treatment plots (T5 and T2), irrespective of

TABLE 9
Effect of intensive cultivation of fodder maize on economics (mean of two crop sequences)

Trt.	TCC (Rs./ha)	1st sequence (Rs./ha)		2nd sequence (Rs./ha)		Mean NR	Mean BCR
		GR	NR	GR	NR		
With FYM @ 25 t/ha							
T1	162896	253740	90844	222600	59704	75274	1.47
T2	130822	191220	60398	211100	80278	70338	1.38
T3	158088	268600	110512	296500	138412	124462	1.80
Mean	150602	237853	87251	243400	92798	90025	1.55
Without FYM							
T4	148956	209940	60984	191500	42544	51764	1.35
T5	116882	166560	49678	185500	68618	59148	1.35
T6	144148	221800	77652	223800	79652	78652	1.55
Mean	136662	199433	62771	200267	63605	63188	1.41

FYM addition or omission. Bama and Babu (2016) also reported the influence of organics on economics of fodder crops. This might be due to higher green fodder yield in the mentioned treatments.

CONCLUSION

The present investigation highlights that, higher green fodder yield of maize with higher profit and BCR could be obtained when three crops of fodder maize (var. African Tall) are cultivated with inclusion of fodder cowpea (var. CO(FC)8) in the cropping sequence along with addition of FYM @25t/ha. Soil analysis report revealed that, among the cropping sequences, green manure included sequence registered higher soil quality parameters. Irrespective of cropping sequences of fodder maize, FYM applied plots @25 t/ha recorded higher nutrient status, organic carbon and microbial population. Final recommendation is, to meet out the heavy fodder demand, for economic point of view, three crops of fodder maize with fodder cowpea could be recommended. However to maintain soil fertility in soil fertility point of view three crops of fodder maize with green manure cultivation can be recommended .

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