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Effect of organic mulches and green manuring on growth, yield and economics of maize (*Zea mays* L.) in Alfisols of eastern dry zone of Karnataka

[1]Md. Majeed Pasha,[1]K. S Rajashekarappa, [2]T. Chikkaramappa,[3]Thimmegowda M. N
[4]K. Devaraja and [5]K.S. Somashekar
[1]Department of Agricultural Engineering, [2]Department of Soil Science and Agricultural Chemistry,
[3,4]AICRP on Dryland Agriculture and[5]Department of Agronomy
University of Agricultural Sciences, GKVK, Bengaluru-560065
E-mail: 786012pasha@gmail.com

ABSTRACT
A field experiment was studied in Alfisols of Eastern Dry Zone of Karnataka University of Agricultural Sciences, GKVK, Bengaluru, during kharifto know growth yield and Economics of maize. The soil of experimental site was red sandy loam in texture ,slightly acidic low in available nitrogen, low in available Nitrogen, medium in available Phosphorous and Potassium. The experiment consisted of 9 treatments viz, mulching with paddy straw, mulching with dry leaves, mulching with coconut fronds, mulching with saw dust, horse gram in situ green manuring, sunhemp in situ green manuring, glyricidia green leaf manuring, pongamia green leaf manuring and control which was replicated thrice and laid out in RCBD. Growing of sunhemp in between maize rows as intercrop and incorporating as in situ green manuring resulted in better growth of the crop viz., higher plant height 154.17, 170.42 and 226.33 cm at 60, 90 DAS and at harvest, respectively number of leaves, leaf area index and leaf area duration, absolute growth rate, net assimilation rate, crop growth rate and relative growth rate and yield parameters at harvest viz., number of cobs per plant (1.67), cob length (16.91 cm), cob diameter (17.02 cm), number of grains row per cob (16.67), number of grains per row (35) and 100 seed weight of grains (37.74 gm), grain yield (7442kg ha^{-1}) and stover yield (9470kg ha^{-1}).The highest gross income (Rs.77991ha^{-1}) net income (Rs. 51088ha^{-1}) and B:C ratio (2.90) was also obtained with same treatment.
Keywords: organic mulches, green manuring, maize

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INTRODUCTION

Maize is the third most important cereal crop after rice, wheat and is an important staple food in many countries of the world. It is also known as the Miracle Crop or Queen of Cereals due to its high productivity potential in the poaceae family. Maize is extensively grown in developed countries and consumed mainly as second-cycle produce, in the form of meat, eggs and dairy products. In developing countries, maize is consumed directly and serves as staple diet for 200 million people. In Karnataka, maize is grown over an area of 1.18 million hectares with production of 3.27 million tonnes and average productivity of 27.73 q ha^{-1} [7]. In our state most of the traditional crops like cotton, groundnut, ragi, sorgum have been replaced by maize. Maize is considered as exhaustive crop and depletes the soil moisture and nutrients from deeper layer of soil resulting in loss of soil fertility. A sustainable yield can be achieved through moisture conservation and addition of organic matter. Among various moisture conservation practices, mulching is one of the technology, which assumes greater importance. Mulching is the process of covering the surface soil with various organic materials, which mainly constitutes crop residues and polythene sheets. Besides this, it is having favorable effect on physical, chemical and biological properties, soil aggregates stabilization, enhance soil organic matter, soil nutrients, reduce runoff and soil erosion by intercepting raindrops, thus reducing soil erosion. Mulches are also useful in reducing evaporation, suppressing weeds and moderating in soil temperature. Further, addition of organic manures, green biomass either through *insitu* green manuring and green leaves in to soil and intercropping of legumes not only add nutrients to soil, also conserve the moisture and resulted in for

improvement in physical, chemical and biological properties of soil. The use of green manure cover crops (GMCC) is one of the low cost technology, which helps in improving soil fertility. Green manure cover crops have several advantages, among them, regulating soil surface temperatures due to their higher surface ground cover, increasing soil organic matter content to the soil thus improving soil physical properties, controlling soil erosion and conserving soil [8].

MATERIAL AND METHODS

Field experiment was carried out in Alfisols of Eastern Dry Zone of Karnataka, University of Agricultural Sciences, GKVK, Bengaluru during kharif season of 2017. The soil was red sandy loam in texture having 36.16, 33.84 and 21.47% of coarse sand, fine sand and clay content respectively. The soil was slightly acidic in pH (5.80) and low available N (159 kg ha^{-1}), medium in available P_2O_5(17.6 kg ha^{-1}) and available k_2O (109 kg ha^{-1}). The experiment consisted of nine treatments involving mulching with paddy straw(T_1), mulching with dry leaves(T_2), mulching with coconut fronds(T_3) mulching with saw dust(T_4), Horse gram *insitu*green manuring(T_5), sunhemp*insitu* green manuring(T_6), Glyricidia green leaf manuring(T_7), Pongamia green leaf manuring(T_8) and control (T_9). The treatments were laid out in complete randomized block design and replicated thrice. The intercrop for insitu green manure crop and horse gram were sown along with main crop in 1:1 and green manure crop was incorporated at 30DAS row ratio without altering the maize population.

Five plants were randomly selected from net plot area and tagged for recording various observations on growth parameters at 60, 90 DAS and at harvest. The yieldand the yield components were recorded. The data on various parameters were subjected to statistical analysis to draw the interpretation of the data.

RESULT AND DISCUSSION

Growth and growth attributes:the data revealed that significant difference was observed among the growth components with respect to different treatments at 60, 90 DAS and at the harvest. Among different treatments insitu green manuring with sunhemp at 30 DAS recorded significantly higher growth parameters viz., plant height (154.17 cm, 170.42 cm and 226.33 cm, respectively), number of leaves $plant^{-1}$ (12.47, 13.82 and 10.62 respectively),leaf area (4780, 7878 and 2038 cm^2plant^{-1}respectively), leaf area index (2.66, 4.38 and 1.13 respectively) at the 60 DAS and at harvest. The similar trends was also observed with leaf area duration (105.49 and 82.64 g $days^{-1}$) absolute growth rate (11.56 and 4.38 g $days^{-1}$), crop growth rate (64.24 and 5.57 days) and relative growth rate (0.03 and 0.0016 g $days^{-1}$) between 60-90 DAS and 90 DAS to harvest. The increased crop performance viz., AGR, NAR, CGR and RGR was due to increased plant height, no of leaves $plant^{-1}$, leaf area, dry matter, leaf area index and leaf area duration. Insitu green manuring of sunhemp between the maize rows resulted in higher growth attributes as compared to other treatments this might be due to incorporation of sunhemp in to the soil helps in improving the soil moisture content which results in better uptake if moisture from each plant in the treatment. Upon decomposition sunhemp released nutrient in to the soil and resulted in better uptake by the plant. The combined effect of increased moisture and nutrient helps in cell turgidity and eventually higher meristematic activity leading to more foliage development, greater photo synthetic rate which was manifested in terms of higher dry matter. These results are conformity with the earlier findings [1, 2, 3]

Table 1. Plant height and number of leaves of maize at different growth stages as influenced by differentorganic mulches and green manuring

Treatment	Plaint height (cm)			No. of leaves $plant^{-1}$		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1 : Mulching with paddy straw	140.63	152.63	205.67	11.30	12.60	11.10
T_2 : Mulching with dry leaves	139.50	149.07	187.00	11.17	12.20	10.90
T_3: Mulching with coconut fronds	137.73	146.30	177.00	11.00	11.90	10.62
T_4: Mulching with saw dust	136.33	145.67	176.67	10.80	11.70	10.47
T_5: Horse gram (*insitu* green manuring)	144.83	161.67	216.00	11.64	13.10	12.40
T_6: Sunhemp (*insitu* green manuring)	154.17	170.42	226.33	12.47	13.82	13.20
T_7: Glyricidia (*exsitu* green manuring)	149.33	163.00	220.67	12.03	13.63	11.53
T_8: Pongemia (*exsitu* green manuring)	142.67	156.90	207.00	11.40	12.80	11.17
T_9: Control.	129.50	142.83	168.00	10.73	11.46	10.37
S.Em±	**4.12**	**5.67**	**10.02**	**0.76**	**0.48**	**0.56**
CD (P =0.05)	**12.34**	**17.00**	**30.03**	**NS**	**1.43**	**1.68**

NS – Non significant, DAS – Days after sow

Table 2. Leaf area and dry matter of maize at different growth stages as influenced by different organic mulches and green manuring

Treatment	Leaf Area (cm^2 $plant^{-1}$)			Dry Matter (g $plant^{-1}$)		
	60 DAS	90 DAS	At harvest	60 DAS	90 DAS	At harvest
T_1 :Mulching with paddy straw	4183	6389	1711	208.50	540.08	531.50
T_2 :Mulching with dry leaves	3985	6091	1584	190.88	510.07	509.33
T_3:Mulching with coconut fronds	3811	6088	1528	188.73	513.20	503.07
T_4:Mulching with saw dust	3671	5927	1515	185.75	466.10	458.33
T_5:Horse gram (*insitu* green manuring)	4257	7473	1786	256.59	569.11	561.67
T_6:Sunhemp (*insitu* green manuring)	4780	7878	2038	285.11	622.67	618.25
T_7:Glyricidia (*exsitu* green manuring)	4555	7576	1996	278.67	598.67	585.33
T_8:Pongemia (*exsitu* green manuring)	4216	6750	1744	213.33	555.33	542.10
T_9:Control.	3264	5440	1445	163.35	421.07	430.00
S.Em±	**279.85**	**437.27**	**92.47**	7.62	**18.28**	**20.34**
CD (P =0.05)	**838.99**	**1310.93**	**277.23**	22.85	**54.80**	**60.99**

Table 3. Leaf area index and leaf area duration of maize at different growth stages as influenced by different organic mulches and green manuring

Treatment	Leaf area index			Leaf area duration (days)	
	60 DAS	90 DAS	At harvest	Between 60-90 DAS	Between 90 - at harvest
T_1 :Mulching with paddy straw	2.32	3.55	0.95	88.10	67.50
T_2 :Mulching with dry leaves	2.21	3.38	0.88	83.97	63.96
T_3:Mulching with coconut fronds	2.12	3.38	0.85	82.49	63.48
T_4:Mulching with saw dust	2.04	3.29	0.84	79.99	62.02
T_5:Horse gram (*insitu* green manuring)	2.37	4.15	0.99	97.75	77.16
T_6:Sunhemp (*insitu* green manuring)	2.66	4.38	1.13	105.49	82.64
T_7:Glyricidia (*exsitu* green manuring)	2.53	4.21	1.11	101.10	79.78
T_8:Pongemia (*exsitu* green manuring)	2.34	3.75	0.97	91.39	70.78
T_9:Control.	1.81	3.02	0.80	72.54	57.38
S.Em±	**0.16**	**0.24**	**0.05**	**2.95**	**3.66**
CD (P=0.05)	**0.47**	**0.73**	**0.15**	**8.83**	**10.97**

Table 4. Absolute growth rate and net assimilation rate of maize at different growth stages as influenced by different organic mulches and green manuring

Treatment	Absolute growth rate (g $days^{-1}$)		Net assimilation rate (days)	
	Between 60-90 DAS	Between 90 - at harvest	Between 60-90 DAS	Between 90 - at harvest X 10^{-5}
T_1 :Mulching with paddy straw	10.54	3.55	0.0018	4.22
T_2 :Mulching with dry leaves	9.92	3.38	0.0018	4.01
T_3:Mulching with coconut fronds	10.03	3.38	0.0018	3.21
T_4:Mulching with saw dust	8.58	3.29	0.0018	2.82
T_5:Horse gram (*insitu* green manuring)	10.17	4.15	0.0020	4.94
T_6:Sunhemp (*insitu* green manuring)	11.56	4.38	0.0020	11.00
T_7:Glyricidia (*exsitu* green manuring)	11.14	4.21	0.0020	5.24
T_8:Pongemia (*exsitu* green manuring)	10.51	3.75	0.0019	4.30
T_9:Control.	7.86	3.02	0.0017	2.30
S.Em±	**0.83**	**0.24**	**0.0014**	**1.50**
CD (P=0.05)	**NS**	**0.73**	**NS**	**4.58**

Table 5. Crop growth rate and relative growth rate of maize at different growth stages as influenced by different organic mulches and green manuring

Treatment	Crop Growth Rate (days)		Relative Growth Rate (days)	
	Between 60-90 DAS	Between 90 - at harvest	Between 60-90 DAS	Between 90 - at harvest
T_1 :Mulching with paddy straw	58.58	8.36	0.03	0.0027
T_2 :Mulching with dry leaves	55.12	9.75	0.03	0.0034
T_3:Mulching with coconut fronds	55.74	7.70	0.03	0.0027
T_4:Mulching with saw dust	47.68	8.83	0.03	0.0033
T_5:Horse gram (*insitu* green manuring)	56.50	6.99	0.03	0.0022
T_6:Sunhemp (*insitu* green manuring)	64.24	5.57	0.03	0.0016
T_7:Glyricidia (*exsitu* green manuring)	61.88	6.36	0.03	0.0019
T_8:Pongemia (*exsitu* green manuring)	58.41	8.25	0.03	0.0026
T_9:Control.	43.69	18.70	0.03	0.0071
S.Em±	**4.59**	**2.85**	**0.00**	**0.0010**
CD (P=0.05)	**NS**	**NS**	**NS**	**NS**

Yield and yield attributes: yield and yield attributes of maize was found to be significant with respect to different organic mulches and green manuring treatments. Significantly higher grain yield (7442 kg ha^{-1}) and straw yield (9470 kg ha^{-1}) was obtained with *insitu* green manuring of sunhemp as compared to all other treatments. The higher seed yield and grain yield of maize was due to higher yield attributing parameters viz., cob length (16.91 cm), cob girth (17.02) cm), number of grains cob^{-1} (532.83), number of rows cob^{-1} (16.67 cm) number of grains row^{-1} (35.07) and 100 seed weight (37.74 g) as compared to control treatments. The higher yield attributing parameters in *insitu* green manuring of sunhemp might be attributed to higher growth and growth attributes. The *insitu* incorporation sunhemp in to the soil resulted in increasing the organic matter content of the soil, which in turn results in availability of macro and micronutrients in the soil pool for a longer period of time which matches the nutrient uptake of the maize crop. Similar findings were also reported by [5, 6, 3, 4].

Table 6. Yield attributing characters of maize as influenced by different organic mulches green manuring

Treatment	Cob length (cm)	Cob Diameter (cm)	No. of grains cob^{-1}	No. of row^{-1} cob^{-1}
T_1 :Mulching with paddy straw	15.75	15.66	473.73	15.17
T_2 :Mulching with dry leaves	15.37	15.54	458.07	15.00
T_3:Mulching with coconut fronds	14.97	14.97	433.73	14.67
T_4:Mulching with saw dust	14.60	14.54	424.20	13.67
T_5:Horse gram (*insitu* green manuring)	16.27	15.69	492.81	15.67
T_6:Sunhemp (*insitu* green manuring)	16.91	17.02	532.83	16.67
T_7:Glyricidia (*exsitu* green manuring)	16.73	16.33	523.13	16.33
T_8:Pongemia (*exsitu* green manuring)	15.80	15.67	484.00	15.33
T_9:Control.	13.42	14.16	399.47	12.67
S.Em±	**0.68**	**0.51**	**22.60**	**0.76**
CD (P=0.05)	**2.04**	**1.54**	**67.77**	**2.28**

Economics: The insitu green manuring of sunhemp at 30 DAS recorded lower cost of cultivation (Rs. 26903 ha^{-1}) higher gross returns (Rs. 77991 ha^{-1}), net returns (Rs. 51088 ha^{-1}) and B:C ratio (2.90) as compared to all other treatments. The insitu green manuring requires less cost as compared to fertilizers apart from increasing soil moisture and carbon content which results in better uptake of nutrients to yield more as compared to other treatments which leads to higher net returns and B:C ratio.

Table 7. Yield attributes characters of maize as influenced by different organic mulches and green manuring

Treatment	No. of grains row^{-1}	100 seed weight (g)	Grain yield (kg ha^{-1})	Stover yield (kg ha^{-1})
T_1 : Mulching with paddy straw	28.33	33.90	6851	8638
T_2 : Mulching with dry leaves	28.03	33.85	6536	8087
T_3: Mulching with coconut fronds	27.67	32.81	6459	8198
T_4: Mulching with saw dust	27.13	32.51	6448	7282
T_5: Horse gram (*insitu* green manuring)	30.67	36.14	7290	9256
T_6: Sunhemp (*insitu* green manuring)	35.07	37.74	7442	9470
T_7: Glyricidia (*exsitu* green manuring)	33.73	37.19	7325	9305
T_8: Pongemia (*exsitu* green manuring)	29.67	34.38	7150	9059
T_9: Control.	26.33	32.55	5887	8071
S.Em±	**1.29**	**1.13**	**231.78**	**325.37**
CD (P=0.05)	**3.88**	**3.40**	**694.87**	**975.45**

Table 8. Economics of maize (Rs ha^{-1}) as influenced by different organic mulches and green manuring

Treatment	Total gross returns	Total cost of cultivation (Rs ha^{-1})	Net returns (Rs ha^{-1})	B:C ratio
T_1 : Mulching with paddy straw	72830	28103	44727	2.59
T_2 : Mulching with dry leaves	68634	26140	42494	2.63
T_3: Mulching with coconut fronds	62972	26063	36909	2.42
T_4: Mulching with saw dust	69007	31103	37904	2.22
T_5: Horse gram (*in situ* green manuring)	77531	29103	48428	2.66
T_6: Sunhemp (*in situ* green manuring)	77991	26903	51088	2.90
T_7: Glyricidia (*ex situ* green manuring)	78241	28803	49438	2.72
T_8: Pongemia (*ex situ* green manuring)	76038	29103	46935	2.61
T_9: Control.	62246	23103	39143	2.69

CONCLUSION

In situ green manuring of sunhemp helps in increasing significantly higher yield and yield attributes in maize and helps in obtaining higher net returns and B:C ratio as compared to other green manuring and organic mulch treatments. This technology may widely adopted by farmers to conserve soil moisture in *alfisols* of Easter dry zone of Karnataka.

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