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Studies on the Effect of Green Manure *in-situ* Incorporation on Growth and Yield of *kharif* Maize (Zea mays L.)

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ABSTRACT

A field experiment was conducted at the Agricultural College Farm, Bapatla to study the effect of *in-situ* incorporation of green manures on growth and yield of maize. Growth parameters like plant height and drymatter production recorded a significant difference due to *in-situ* incorporation of green manures. Age of green manure incorporation had a significant influence on grain yield of maize. Maximum grain yield (7871 kg ha^{-1}) was recorded when incorporated at 60 days which was found significantly superior to 45 and 30 days of incorporation of green manures. The interaction was not significant.

Key words : Green manure, Growth & Yield, *In-situ* incorporation, Maize.

Leguminous green manures have the potential to reduce the dependency on external N sources and to increase soil organic matter content. Satisfactory supply of N, the most limiting nutrient for plant growth, is often regarded as a 'keystone' property for green manure use. However, the incentives for using green manure is not solely to supply N, but also the potential delivery of multiple services, which could include pest and weed control, increase in soil organic matter, reduction of soil erosion or agrochemical losses or creation of habitats or resources for beneficial organisms.

MATERIAL AND METHODS

The field experiment was conducted during the *kharif* season of 2012-2013 at the Agricultural College Farm, Bapatla. The soil was clay loam in texture, alkaline in reaction with p^H 8.1, low in organic carbon (0.40 %) and available nitrogen (212 kg ha^{-1}), medium in available phosphorus (31 kg ha^{-1}) and potassium (301 kg ha^{-1}). Three different green manure (dhaincha, sunnhemp and pillipesara) and their three different ages of incorporation (60 days, 45 days and 30 days) were tested in factorial RBD with single control (no green manure) and replicated thrice. Data on growth and yield were recorded on marked plants and subjected to statistical analysis.

RESULTS AND DISCUSSION

The data (Table 1) revealed that among different green manure crops, dhaincha (13.8 t/ha) recorded maximum biomass production which was significantly superior to sunnhemp (12.6 t/ha) and pillipesara (9.1 t/ha). A similar significant difference was observed between sunnhemp and pillipesara. Similarly, age of green manures also had a significant effect on biomass production. The 60 days aged green manure recorded maximum (18.1 t/ha) biomass which was found significantly superior to 45 days (10.4 t/ha) and 30 days (7.0 t/ha) aged green manures. Highest biomass was produced with 60 days dhaincha (20.6 t/ha) followed by 60 days sunnhemp (18.8 t/ha) which in turn is followed by dhaincha 45 days (12.7 t/ha). Lowest biomass was produced with 30 days pillipesara (5.3 t/ha). Climatic condition might have favoured the better performance of dhaincha as it can grow in wet as well as dry conditions. Growth of the plant continues from grand growth phase to senescence phase but the growth is slow. Since, dhaincha comes to flowering at 45 to 47 days and there is rapid biomass accumulation upto that stage, biomass accumulation continues even after flowering but, the biomass production slows down. Whereas, sunnhemp comes to flowering by 72 to 74 days that may be the reason for lesser biomass

accumulation by sunnhemp at 60 days than dhaincha at 60 days age. Pillipesara recorded lowest biomass production among all green manures at 60 days age might be because of the genetic potential of the plant as well as the prevailing climatic conditions. Salam *et al*. (1989) also reported similar results which are in tune with the present findings.

Plant height (Table 3) was increased significantly due to age of incorporation of green manures but no significant difference was observed due to incorporation of different green manures; however, their interaction was also found to be non significant. Plant height at 30 DAS recorded maximum when green manures were incorporated at 60 days (100.9 cm) which was significantly superior to 30 days (90.9 cm) incorporation; however, plant height at 60 days and 45 days as well as 45 days and 30 days were remained on a par. Shortest plants were observed in control plot (no green manuring). Plant height in all green manure treated plots was found to be significantly superior to control plot. Similar trend was noticed in at all the stages of the maize crop. More quantity of fresh biomass addition which may release more quantity of nutrients and the time of release of nutrients might have matched with the nutrient uptake by crop as the decomposition of the aged crop is slow which will help to enhance the period of availability of nutrients that matches the nutrient demand of the crop. That may be the reason for significant difference in plant height of maize due to incorporation of green manures at different ages of incorporation. These results are in accordance with the findings of Patel and Kumhar (2010).

The drymatter production (Table 2) recorded significant difference in maize where green manures were incorporated at 60 days followed by 45 and 30 days age of incorporation. No significant difference was observed for drymatter production between different green manures. However, significantly higher drymatter production was observed in all green manure incorporated plots over no green manuring control plot. Drymatter production in maize at 30 DAS was highest when incorporation of green manures was done at 60 days (1069 kg ha^{-1}) which was significantly superior to 45 days (960 kg ha^{-1}) and 30 days (950 kg ha^{-1}) of incorporation whereas, drymatter production in maize where 45 days and 30 days aged green manure incorporated plots were remained statistically on a par with each other. Least drymatter production (858 kg ha^{-1}) was recorded in control plot, however significant, differences were observed in all green manure treated plots compared to control. No interaction effect was observed between green manures and age of their incorporation. Similar trends were observed for drymatter accumulation in maize at remaining stages.

Large quantity of dhaincha, sunnhemp and pillipesara biomass (Table 1) was incorporated before sowing of maize. The contribution of this large quantity of organic matter might have increased the growth parameters. This better performance could be attributed to increased total soil N resulted likely from biological fixed N and mineralized N from decomposed incorporated legume materials as well as the improvement observed in the soil organic matter and soil available P after legumes incorporation. This might have facilitated better uptake and accumulation of these nutrients for better maize growth and consequently, increased dry matter yields. The result is in conformity with Gangawar and Kalra (1981).

Test weight (Table 3) was significantly differed due to age of incorporation of green manures only. The highest test weight was recorded with 60 days (32.8 g) age of incorporation which was found significantly superior to 30 days (31.2 g) age of incorporation. Similarly, 45 days (32.3 g) incorporated green manure differed significantly over 30 days incorporated green manure. But, test weight of maize recorded from 60 days and 45 aged green manure incorporated plots was remained at a par with each other. The minimum test weight was observed with control (30.0 g). All green manure treated plots were found to be significantly superior to control. Though test weight is a genetic character, but due to its good management, weight of maize increased progressively with increased quantity of green manure biomass added to the soil. There might be some positive influence of legume green manure on yield attributes such as test weight and grain weight per cob. The results were in conformity with those of Lakshmi *et al.* (2009).

Data (Table 3) reveals that the number of cobs per plant due to *in-situ* incorporation of green

Table 1. Green manure crops biomass production (t ha^{-1}) before incorporation as influenced by *in-situ* incorporation of green manures and age of their incorporation.

Green Manures	Age of green manure incorporation			
	60 DAS	45 DAS	30 DAS	MEAN
Dhaincha	20.6	12.7	8.1	13.8
Sunnhemp	18.8	11.4	7.5	12.6
Pillipesara	12.0	7.1	5.3	9.1
MEAN	18.1	10.4	7.0	
Control	0			
	Sem ±	C D (P=0.05)	C V (%)	
Green Manures	0.51	1.0	10.6	
Age of Incorporation	0.51	1.0		
Interaction (G x A)	0.89	1.8		
Control Vs treated	0.94	1.9		

Table 2. Drymatter production (kg ha^{-1}) at different stages of maize as influenced by *in- situ* incorporation of green manures and age of their incorporation.

Treatments	Dry matter production (kg ha^{-1}) of maize			
	30 DAS	60 DAS	90 DAS	At harvest
Green Manures	1037	5811	14818	17595
Dhaincha	1008	5637	14195	17280
Sunnhemp	933	5396	13515	16248
Pillipesara	43.4	183.5	679.6	604.5
S Em ±	NS	NS	NS	NS
C D (P=0.05)				
Age of GM incorporation	1069	5942	15603	18194
60 DAS	960	5569	14017	16728
45 DAS	950	5332	12907	16201
30 DAS	43.4	183.5	679.6	604.5
S Em ±	91	386	1428	1270
C D (P=0.05)	858	5085	12289	15364
Control	993	5615	14176	17041
Control Vs treated	79.3	335.0	1240.7	1103.7
S Em ±	167	704	2607	2319
C D (P=0.05)				
Interaction (G x A)	75.2	317.8	1177.1	1047.1
S Em ±	NS	NS	NS	NS
C D (P=0.05)	9.4	7.0	10.3	7.6
C V (%)				

Table 3. Growth and yield of maize as influenced by *in-situ* incorporation of green manures and ages of their incorporation.

Treatments	Plant height (cm) of maize				Days to 50 % tasseling	Days to 50 % silking	Cobs (No.) plant^{-1}	Test wt. (g/100 grains)	Kernel yield (kg ha^{-1})	Stover yield (kg ha^{-1})
	30 DAS	60 DAS	90 DAS	At harvest						
Green Manures										
Dhaincha	99.0	241.6	250.9	253.0	56.3	60.4	1.11	32.4	7475	8986
Sunnhemp	97.4	238.2	245.8	246.8	56.4	61.1	1.11	32.1	7274	8812
Pillipesara	90.7	231.7	235.3	240.9	57.0	62.2	1.07	31.8	6763	8319
S Em ±	3.70	4.86	6.48	5.87	0.55	0.69	0.05	0.50	366.1	301.6
C D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Age of GM incorporation										
60 DAS	100.9	245.7	254.6	257.0	55.6	59.9	1.13	32.8	7871	9182
45 DAS	95.3	235.6	242.9	245.2	56.9	61.6	1.11	32.3	7030	8644
30 DAS	90.9	230.2	234.6	238.5	57.3	62.3	1.04	31.2	6611	8290
S Em ±	3.70	4.86	6.48	5.87	0.55	0.69	0.05	0.50	366.1	301.6
C D (P=0.05)	7.8	10.2	13.6	12.3	1.1	1.0	NS	1.0	769	634
Control	83.2	220.6	224.1	226.0	58.7	63.7	1.00	30.0	5761	7478
Control Vs treated	95.7	237.1	252.5	246.9	56.6	61.3	1.10	32.1	7170	8705
S Em ±	6.76	8.88	11.83	10.71	1.00	1.26	0.09	0.86	668.5	550.6
C D (P=0.05)	14.2	18.7	24.9	22.5	2.1	2.6	NS	1.9	1404	1157
Interaction (G x A)										
S Em ±	6.42	8.38	11.22	10.16	0.95	1.19	0.08	0.9	634.2	522.3
C D (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
C V (%)	8.3	4.4	5.7	5.1	2.1	2.4	9.57	3.3	11.2	7.5

manures was not significant. Age of incorporation of green manures only had a significant influence on the shelling percentage. Maximum shelling % was obtained with 60 days age of incorporation (84.3) which was significantly differed with 30 days age of incorporation (82.9). Similarly, shelling % in 45 days age (83.8) of incorporation was found to be significantly superior to 30 days age (82.9) of incorporation; however, shelling % at 60 days age of incorporation and 45 days age of incorporation didn't differ significantly with each other. Minimum shelling % was observed in control (82.2). All green manure treated plots recorded significantly superior shelling % over control. As test weight varied, the shelling % also followed the same trend.

Statistically analyzed data (Table 3) on kernel yield shows significant variations on kernel yield of maize due to age of incorporation of green manures. No significant difference was found on kernel yield due to incorporation of different green manures and interaction between green manures and their age of incorporation. Age of incorporation had exerted significant differences in kernel yield. Maximum kernel yield was recorded when incorporated at 60 days (7871 kg/ha) which was significantly superior to 45 days (7030 kg/ha) and 30 days (6611 kg/ha) incorporation of green manures. However, kernel yield obtained from 45 days and 30 days aged incorporated green manure did not attain the level of significance with each other. The minimum kernel yield was observed in control (5761 kg/ha) where no green manure was incorporated. All the green manure treated plots recorded higher kernel yield of maize which was significantly superior to control. Numerically higher kernel yield was recorded with green manure crop, dhaincha (7475 kg/ha) than sunnhemp (7274 kg/ha) and pillipesara (6763 kg/ha). All these three green manure crops remained at a par with one and another.

Higher kernel yield was recorded at 60 days age of incorporation. Increase in yield in this treatment may be due to higher cob weight and test weight. The cob weight at 60 days age of incorporation was significantly superior to any other treatment combination. Similarly, test weight recorded in maize at 60 days age of incorporation was superior to other treatments. Green manures added large quantity of organic biomass. The percentage increase in kernel yield due to 60 days, 45 days and 30 days age of incorporation over control was 36.6 %, 22.0 % and 14.8 %, respectively. When green manures are turned under at the time of flowering, the decomposition starts immediately in the soil. The green leaves, flowers, immature pods and vegetative buds decompose very rapidly as they contain simple sugars, starches, hemicelluloses, amino acids, amides and aldehydes which are hydrolyzed readily by heterotrophic bacteria (Tandon, 1992). Ammonification starts within two days. These are called "Rapid-N" liberators. The aged shoots, roots, and other woody parts are resistant to decomposition as they contain complex lignin compounds. Biological processes are very slow on these parts and termed as "Slow-N" liberators. The initial fraction (Rapid-N) supplies N at the time of crop establishment and early tillering. The second and third fractions (Slow-N), which are 20-50% of total N, contribute to nutrition at the reproductive phase of crop. About 40% of carbon and 80% of total N present in Sesbania were released in about two weeks. Since, 60 days aged green manure has both the rapid N liberator and slow N liberator and it might have provided the nutrients to maize crop according to their demand from initial stage to reproductive stage. Green manure incorporation preceding the maize might have helped in maintaining the buildup of soil organic matter, which in turn, helped in improving the soil's structure, pore size and water-holding capacity, increase in microbial population in rhizosphere of maize which might helped in better availability of nutrients including micronutrients by reducing the loss of nutrients and improving the fertilizer use efficiency. Such observations were also reported by Patel and Kumhar (2010) and Fabunmi *et al.* (2012).

The data on stover yield (Table 3) indicates significant differences in stover yield due to age of incorporation of green manures only but no significant difference was observed due to either different green manures or their interaction. With the increased age of incorporation of green manures the stover yield was found to increase. Maximum stover yield (9182 kg ha^{-1}) was obtained when they were incorporated at 60 days which was significantly superior to 30 days incorporated green manure where stover yield obtained was (8290 kg

ha^{-1}), whereas stover yield was on a par with each other in case of 60 days and 45 days incorporated green manure as well as 45 days and 30 days incorporated green manure. The lowest stover yield (7478 kg ha^{-1}) was observed with control. All green manure treated plots recorded significantly higher stover yield over control. The percentage increase in stover yield due to 60 days, 45 days and 30 days age of incorporation over control was 22.7 %, 15.5 % and 10.8 % respectively.

More quantity of green manure biomass addition might have added macro and micro nutrients which may contribute for better availability of nutrients for longer duration. Increased organic carbon content during crop period might have increased fertilizer use efficiency as it withholds the nutrients and prevent them from getting lost due to leaching. Besides, increased organic carbon might have contributed for increase in microbial population which is the food for microorganisms which, in turn, would have contributed for the nutrient transformations occurring in the soil and their better availability to the plants. Itnal and Palled (2001) have also reported that yield and yield attributing characters increases due to incorporation of green manures.

CONCLUSION

Growth parameters viz; plant height and dry matter production recorded a significant difference due to *in-situ* incorporation of green manures. Significantly higher kernel yield was recorded with 60 days age of green manure incorporation over 45 and 30 days age of green manure incorporation.

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