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Biomass Production and Decomposition Rate as Influenced By Age of Green Manures and Their Effect on Yield of *Kharif* Maize

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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 dhaincha, sunnhemp and pillipesara green manure at 60, 45 and 30 DAS. Highest biomass production was recorded from 60 days aged dhaincha. Age of incorporation had exerted significant differences in grain yield. Maximum grain 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. Similar results were obtained for other yield parameters such as cob weight and test weight etc. Due to age of incorporation of green manure, maximum undecomposed portion was observed at 60 days (4.57 t/ha) age of incorporation followed by 45 days (1.46 t/ha) and 30 days (0.60 t/ha) age of incorporation, but all these were found to be significantly superior to one and another.

Key words : Green manure, Biomass, Undecomposed portion.

Due to intensive farming, the farmer do not get sufficient time gap to grow green manures. Farmers are not ready to sacrifice the main crop for the sake of growing green manure crop and incorporate it. However, if a green manure crop is grown with the early showers and incorporated before sowing of a *kharif* crop, it will add considerable quantity of biomass to the soil. The effectiveness of green manure crop, however, is related to its ability to produce more biomass and to sequester large amounts of plant nutrients in a short period of time. To improve the soil physical and chemical properties, growing and incorporation of green manure crops may be a promising practice in the years to come for sustainable agriculture.

MATERIAL AND METHODS

The field experiment was conducted during the *kharif* season of 2012 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 crops (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. First sowing of green manure was done on 15th May followed by 2nd and 3rd sowing at 15 days interval. Maize was planted at an inter- and intra-row spacing of 75 cm x 20 cm on 11th of August and harvested on 24th of November. Seeds of green manure crops were broadcasted @ *Dhaincha* (50 kg/ha), *Sunnhemp* (30 kg/ha) and *Pillipesaera* (15 kg/ha). An area of $1m^2$ was selected with a quadrant at random in every plot of green manure crop and was cut to ground level so as to record fresh biomass production before the incorporation. The fresh weight of biomass was expressed in t /ha^{-1}.

Undecomposed green manure biomass portion was determined 45 days after incorporation of green manures using soil core. Soil core was driven up to 10 cm depth and samples were collected from each plot. Collected soil samples were placed and shaken in water. By filtering the water, undecomposed green manure biomass was separated which was weighed. Volume of soil core (which was cylindrical in shape) was determined by using the formula $\pi r^2 h$. The diameter of the soil core used was 7 cm.

Thus, the volume of the collected soil sample is

$$\pi r^2 h = \frac{22}{7} \times 3.5 \times 3.5 \times 10 \text{ cm}^3 = 385 \text{ cm}^3$$

By computation, the total volume of soil in a hectare is calculated as 10,000 m^2 x 10 cm = 10^9 cm^3. Quantity of undecomposed green manure biomass portion present in 385 cm^3 soil core was converted to undecomposed green manure biomass per hectare to a depth of 10 cm.

RESULTS AND DISCUSSION

The maximum biomass production was recorded in dhaincha (13.8 t ha^{-1}) which is significantly superior to sunnhemp (12.6 t ha^{-1}) and pillipesara (9.1 t ha^{-1}). The 60 days aged green manure recorded maximum biomass (18.1 t ha^{-1}) which was found significantly superior to 45 days (10.4 t ha^{-1}) and 30 days (7.0 t ha^{-1}) aged green manures. Highest biomass was produced in 60 days dhaincha (20.6 t/ha) followed by 60 days sunnhemp (18.8 t ha^{-1}) which in turn is followed by dhaincha 45 days (12.7 t ha^{-1}). Least biomass was produced by pillipesara at 30 days (5.3 t ha^{-1}). Climatic condition might have favoured the better performance of dhaincha as it can grow in wet as well as dry conditions. Growth rate of the plant is slow in the initial stage as plants are in lag phase. Maximum growth and biomass production occurs in grand growth phase. 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, there is rapid biomass accumulation upto that stage, biomass accumulation continues even after flowering but, the biomass accumulation 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 least biomass 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. Earlier Bharadwaj *et al.* (1981) also reported similar results.

Dhaincha incorporated plots recorded maximum undecomposed portion (3.69 t/ha) followed by sunnhemp (1.94 t/ha) and pillipesara (1.00 t/ha) incorporated plot. Due to age of incorporation of green manure, maximum undecomposed portion was observed at 60 days (4.57 t/ha) age of incorporation followed by 45 days (1.46 t/ha) and 30 days (0.60 t/ha) age of incorporation. Among all treatments, highest undecomposed portion was observed where dhaincha was incorporated at 60 days (7.90 t/ha) followed by sunnhemp incorporated at 60 days (3.81 t/ha) and dhaincha incorporated at 45 days (2.23 t/ha). Rate of decomposition of green manure depends on several factors viz; moisture, temperature, aeration, quantity and the quality (woodiness, synthesis of complex organic compounds such as lignins and tannins) of green manure. The results were in conformity with those of Muhr *et al.* (1999).

Data in succeeding maize crop (Table 3) show that number of kernels per cob shows that number of kernels per cob was significantly influenced by the age of incorporation of green manures only. The highest number of kernels per cob was observed at 60 days age of incorporation of green manures (533) which was significantly superior to 30 days age of incorporation (476) kernels per cob whereas kernels per cob from 60 days (533) and 45 days (493) as well as 45 days (493) and 30 days (476) incorporated green manure plots were remained on a par with each other. The minimum number of kernels was observed in control (428). However, all the green manure plots recorded more number of kernels and found significantly superior to control. Increase in age of incorporation of green manures not only provided higher quantity of biomass but also added higher quantity of nutrients, increased the organic carbon content of the soil, improved the soil physical condition, enhanced microbial activity in soil which ultimately contributed towards better availability of nutrients and congenial condition for growth and development of the plant. The phasic release of nitrogen from green manure coupled with the application of fertilizer-N resulting in the continuous supply of nitrogen might have supported photosynthesis long enough during grain-filling for increased number of filled kernels. The results are in agreement with finding of Okpara *et al.* (2003).

Cob weight was observed higher when incorporation of green manure was done at 60 days (207.5 g) which was found significantly superior to 30 days (185.9 g) age of incorporation. Cob weight recorded from 60 and 45 days aged green manure was on a par with each other. The Lowest cob weight (172.3 g) was observed in control. All the green manure treated plots recorded a significantly

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.

	Age of Green Manure Incorporation			
Green Manures	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. Undecomposed green manure biomass portion (t ha^{-1}) at 45 day after incorporation of green manures as influenced by *in-situ* incorporation of green manures and age of their incorporation.

	Age of Green Manure Incorporation			
Green Manures	60 DAS	45 DAS	30 DAS	MEAN
Dhaincha	7.90	2.23	0.94	3.69
Sunnhemp	3.81	1.25	0.76	1.94
Pillipesara	1.99	0.90	0.11	1.00
MEAN	4.57	1.46	0.60	
Control	0.00			
	Sem ±	C D (P=0.05)	C V (%)	
Green Manures	0.07	0.14	7.5	
Age of Incorporation	0.07	0.14		
Interaction (G x A)	0.12	0.25		
Control Vs treated	0.12	0.26		

higher cob weight (196.7 g) over control. Better growth and development of the plant might have promoted better development of the cob and filling of kernels. More number of kernels per cob might be the reason for increased cob weight.

Test weight significantly differed with each other due to age of incorporation. The highest test weight was recorded with 60 days (32.8 g) and 45 days (32.3 g) age of incorporation which was found significantly superior to 30 days (31.2 g) age of incorporation, however 60 days and 45 days aged green manure incorporated plot 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 was 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 kernel weight per cob. Such observation was also reported by Lakshmi *et al.* (2009).

Age of incorporation had exerted significant differences in kernel yield. Maximum kernel yield was recorded when green manure 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

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

Treatments	Cob length (cm)	Kernels (No.) cob^{-1}	Cob weight (g)	Test wt. (g/100 kernels)	Kernels yield (kg ha^{-1})	Stover yield (kg ha^{-1})
Green Manures						
Dhaincha	19.0	520	202.4	32.4	7475	8986
Sunnhemp	18.6	509	196.6	32.1	7274	8812
Pillipesara	17.8	471	191.1	31.8	6763	8319
S Em ±	0.58	20.5	6.52	0.50	366.1	301.6
C D (P=0.05)	NS	NS	NS	NS	NS	NS
Age of GM incorporation						
60 DAS	19.6	533	207.5	32.8	7871	9182
45 DAS	18.1	493	196.6	32.3	7030	8644
30 DAS	17.6	476	185.9	31.2	6611	8290
S Em ±	0.58	20.5	6.52	0.50	366.1	301.6
C D (P=0.05)	1.2	43	13.7	1.0	769	634
Control	16.7	428	172.3	30.0	5761	7478
Control Vs treated	18.4	500	196.7	32.1	7170	8705
S Em ±	1.06	37.5	11.90	0.86	668.5	550.6
C D (P=0.05)	2.2	79	25.0	1.9	1404	1157
Interaction (G x A)						
S Em ±	1.01	35.6	11.29	0.9	634.2	522.3
C D (P=0.05)	NS	NS	NS	NS	NS	NS
C V (%)	6.8	9	7.1	3.3	11.2	7.5

level of significance with each other. The minimum kernels 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 one and another. 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. Incorporation and decomposition of green manure has a solubilising effect of N, P, K, and micronutrients (Zn, Fe, Mn, and Cu) in the soil (Saraf and Patil, 1995) and deficiency of different nutrient elements can be mitigated by way of recycling of nutrients through green manuring. Further, it also reduces the leaching and gaseous losses of N, thus increasing the efficiency of applied plant nutrients. 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 were 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 so it might have provided the nutrients to maize crop according to their demand from initial stage to reproductive stage. Green manure incorporation preceding to maize might have helped in maintaining the buildup of soil organic matter, which in turn, helped in improving the soil structure, pore size and water-holding capacity, increase in microbial population in rhizosphere of maize which might be able to have better availability of nutrients including micronutrients by reducing the loss of nutrients and improving the fertilizer use efficiency. These results are in close conformity with those of Cook *et al.* (2010).

With the increased age of incorporation of green manures the stover yield was found to increased. The Maximum stover yield was obtained when they were incorporated at 60 days (9182 kg ha^{-1}) which was significantly superior to 30 days (8290 kg ha^{-1}) incorporated green manure, whereas stover yield was on a par with each other in case of 60 and 45 days as well as 45 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 microorganism which, in turn, would have contributed for the nutrient transformations occurring in the soil and their better availability to the plants. Results are in accordance with those of Itnal and Palled (2001).

CONCLUSION

From the above study, it can be concluded that dhaincha is the best green manure when it is grown in the month of May before planting of *kharif* maize crop. Maximum kernels yield was observed at 60 days age of incorporation of green manures as the rate of decomposition slows down due to more age and the release of nutrients matches with the uptake pattern of the crop and hence nutrient loss is minimized.

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