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Effects of Green Manure on Crop Performance and Yeild in the Savanna Region of Nigeria: A Review

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Abstract
A review on the effect of green manure on crop performance and yield in the Savanna region of Nigeria was conducted in some parts of the Savanna region through the collection from some of the research works carried out by different researchers. In view of the increasing wave of scarcity and high cost of synthetic fertilizers in Nigeria, following changes in Government policies on subsidy, procurement and distribution of inorganic fertilizers, consequently, resource – poor farmers can no longer afford their use to maintain soil fertility. Therefore, the evaluation of suitability of certain green manure in maintaining and improving soil fertility and crop productivity is imperative. Thus, this study was undertaken with a view to appraising effects of green manure on crop performance and yields. More so that one of the major constraints to crop production in the tropics especially in Northern Savanna region of Nigeria is the inherently low fertility status of most of the soils. Thereby necessitated growing search for many soil fertility improvement techniques. Therefore, adoption of green manure cropping system, which is environmentally friendly and soil improver will be the best option for sustainable crop performance and yield in the Northern Savanna. Hence, it is likely to conclude that introduction of legume green manures in cropping systems would be ecologically friendly and economically justifiable.

1.0. Introduction:

High cost of fertilizer and increasing concern for ecological stability and sustainable soil productivity have led to renewed interest in green manure and organic fertilizers (Jibrin 2002, Fageria, 2007). A green manure crop is simply any crop grown for the purpose of being turned under while green or soon after maturity for soil improvement (Soil Science Society of America, 2008). Research on green manure in West Africa is dated back to 1920's when mucuna was tested as an improved fallow species in South Western Nigeria (Faulkuer, 1934). Since then, a large number of herbaceous legumes have been tested. In many parts of West Africa, Mucuna has been adopted as a low input strategy for addressing the problem of declining soil fertility arising from population pressure, intensive cultivation and shortening fallow periods (Manyoung, et. al; 1999). Apart from improving the soil fertility through its Nitrogen fixing ability, it suppresses weeds (Chikoye, et.al; 2001, Ellitta, 2004), nematode (Osei, et.al; 2010) and controls erosion, Azotonde, 1993). Economically, the cultivated varieties have good forage quality and the grain also has feeding potential best suited for cattle and sheep and can be fed to pigs. (Kay, 1979). Some leguminous green manure crops have the ability to accumulate high amount of N within a short time. In about six (6) weeks, cowpea and soybean could accumulate up to 75 and 115 Kg N / ha respectively (Fageria 2007).

When incorporated into the soil, the green manure decomposes to release the accumulated N for use by subsequent crop. Depending on the type of green manure soil type and management, between 4 to 30 % of the total N assimilated by a subsequent cash crop could come from the mineralization of green manure crop residue (Jackson, 2000; Fageria, 2007). Green manure therefore has the potential for supplying some of the N requirements of cereal crops such as, maize, in low input environments where the cost of adequate use of inorganic fertilizers is beyond the means of the resource poor farmer.

The flow of nutrients in and out of agricultural systems is generally characterized by lower storage capacity, less cycling efficiency, continual loss and net removal of nutrients, unlike natural systems where biomass production is equilibrium with nutrient reserves (Hendrix et al; 1992, Nair, 1996). The prevailing farming system of Savanna region is predominantly rainfed, maize, sorghum, millet, rice, and few leguminous crops in conjunction with rearing of livestock. The soils of the areas are low in fertility especially in N, P and organic matter. The trend of growing cereals continuously in the areas is undoubtedly further depleting the nutrients in the soil which are already low. The sustainability of such agricultural system is therefore, greatly dependent on optimizing the balance between inputs and outputs of nutrients. The use of inorganic fertilizers to alleviate the problems of low soil fertility for successful crop production in the Savanna region is limited by high costs and unreliable availability of inorganic fertilizers, even the few farmers who use fertilizers cannot afford the recommended rates. Hence, the need to seek for affordable and less risky soil nutrient management practices.

The use of organic fertilizers to replenish depletion in soil fertility and reduce pollution to the environment which frequently occurs as a result of continuous use of chemical fertilizers is growing interest worldwide. There is a common phenomenon of degradation of soil quality in Agricultural systems of Nigeria, because most of the farmers add little fertilizers and the crops in turn take much from the soil reservoir, which result to low soil fertility. Therefore the use of organic manures like green manure is one of the most environmental friendly agricultural technologies which improve the soil physical properties, fertility level and micro flora (Adesoji, et al; 2013).

In view of the foregoing, it is therefore possible to reduce, if not completely, the reliance on chemical fertilizers by adopting a cropping system which allows greater use of green manure to supply the nutrients require for crop production and capable of maintaining soil fertility. Therefore, the objective of this review is to evaluate the effect of green manure on crop performance and yield component in the Savanna region of Nigeria.

2.0. DISCUSSION

2.1. Benefits of Green Manure:

In the traditional farming practice, a ground cover by living plant is always maintained. Such plants include creeping type cowpea, groundnut, calabash, pumpkin, sweet potato, squash, centrosema, etc. Inclusion of green manuring legumes in cereal based cropping systems have been reported in various parts of the world to result in significant inputs of N into the soil – plant system, leading to increased yields of the subsequent cereal crops (Ramos, et al; 2001, Fillery, 2001, Cobo, et al; 2002). A green manure is therefore used primarily as a soil amendment and a nutrient source for subsequent crops. The green manure has an advantage over other organic manures in that it can be grown directly in the field and can be incorporated during land preparation or regular weeding operation (Tamiru, 2013). According to Swgh, (1997) the advantages of green manure includes:

⇒ Coverage of soil and reduction of evaporation, leading to increased moisture retention, decreased daily soil temperature fluctuation and increased microbial population and activities.

⇒ Breakage of the impact of raindrops on the soils thereby reducing soil wash and erosion.

⇒ Shading of the soil surface from direct rays of sun and therefore prevent excessive heating of soil during the day.

⇒ Suppression of weeds thus saving nutrients for plant use.

⇒ Addition of nutrients from organic matter.

⇒ N_2 fixation in the grain or fodder production

⇒ If green manure (legumes) is grown in a mixture with a cereal, it can improve the N. economy of the cereals both by contributing N to the soil for uptake by the cereal (often called nitrogen transfer).

2.2. Multistorey Cropping System:

Multistorey cropping system is a form of mixed cropping which is intensification of cropping in time and space dimensions. Crops like maize and creeping type of cowpea, or melon are planted together. The planting of several crops which differ in height, root development and light requirements allows a more efficient use of solar energy, soil nutrients and water (Ruthemberg, 1980).

2.3. Suggested improved techniques for maintaining soil fertility. It is a known fact that productivity of Savanna soils can be sustained under continuous land use if soil erosion is controlled and soil organic matter and soil physical and nutritional characteristics are maintained at a favourable level. The various ways of maintaining a favourable level of organic matter in soils are:

2.3.1. Crop rotation and intercropping:

Legumes / green manure have long been recognized as an important components of crop rotation and of intercrops. Apart from the benefits from N_2 fixation in the grain or fodder production any N contributed to the soil can be used by subsequent companion crops. If a legume is grown in a mixture with a cereal. It can improve the N economy of the cereals both by contributing N to the soil for uptake by the cereal (often called nitrogen transfer) or simply by the legume removing less N than if the cereal was grown as a pure stand (this is sometimes called sparing effect) (Singh, 1997). So far these are what most experiments conducted in Savanna region of Nigeria demonstrate in terms of cereal yield obtained when grown after legumes. Increase in maize grain yield at Savanna (Jones, 1974) and wheat at Kadawa Kano (Singh and Nnadi, 1981) was reported when grown after groundnut and cowpea. The residual effect of groundnut in rotation was additive with the application of fertilizer – N giving an increase in yield of wheat grown after maize and sorghum (Table 1).

As far as maintaining fertility status of the soil is concerned. It was observed that at least N, P and K levels can be maintained when groundnut or cowpea is grown in rotation with cereals. Results obtained by Singh and Nnadi (1981) at Kadawa, Kano clearly indicated that under continuous cultivation with crop rotation of groundnut – wheat and cowpea – wheat, the available N, P and K can be maintained (Table 2)

2.3.2. Effect of green manure on yield of two maize varieties. Studies carried out at Zaria, Kaduna State in 2005, 2006 and 2007 on the green manure crops (Lablab (*Lablab purpureus*), mucuna (*Mucuna pruriens*) and Soybean (*Glycine max* (L) Merrill), a weedy fallow and two varieties of maize (SAMMAZ 12 and SAMMAZ 27). The result indicated that the green manure crops performed significantly better on cob diameter and cob length than the incorporation of weedy fallow in all the three years of the study and their combined means (Table

3). There was no significant difference among the green manure crops on cob diameter and cob length. The combined means showed 6.1, 7.4 and 6.1 % increases in cob diameter and 14.8, 16.5 and 13.9 % increases in cob length over weedy fallow for mucuna, lablab and Soybean, respectively (Table 3) Green manure crops performed significantly better than weedy fallow on number of rows per cob and number of grains per cob in all the years of study and their combined means (Table 4). However, there was no significant difference among green manure crops on number of rows per cob and number of grains per cob. In combined mean, incorporation of mucuna, lablab and soybean increased number of rows per cob by 5.1, 5.1 and 4.4 % and number of grains per cob by 22.7, 23.4 and 19.8 % over weedy fallow, respectively (Table 4). In 2005, mucuna (green manure), performed significantly better than soybean green manure and weedy fallow on grain yield (Table 5). While in combined mean, lablab green manure had significantly higher grain yield (Table 5) than soybean green manure and weedy fallow.

2.3.3. Effect of incorporation stage of green manure crops on total dry matter (DM) and grain yield (t ha^{-1}) of a subsequent maize crop.

A study carried out by (Tamiru, 2013) on the effect of stage at termination of legume green manures on soil organic carbon, yield and economic performance of subsequent maize crop, revealed that the dry matter yield of maize crop succeeding tef, weed fallow and GM legume crops, showed a significant variation ($P \leq 0.05$), where maize DM, succeeding cowpea GM produced the highest means amount compared to the rest. The lowest amount was, however, produced in the plot where maize followed tef. (Table 6). The effect of legume incorporation stage on the Dm yield of the maize crop was also found to be highly significant. In that regard, biomass production of maize crop increased with delayed incorporation of legume crops, where the highest mean was recorded in plots treated at pot – setting stage of growth, attributable to the amount of leguminous materials added into the soil. The study also revealed that the total grain yield of maize crop was significantly affected ($P \leq 0.05$) by the preceding practices where maize crop after cowpea GM gave the highest mean yield, whereas maize after the cereal (tef) yielded the least (Table 6). Similar observations were also made by Sakala, et al; (2004) and Miller, et al; (2011), whereby grain yields of cereals following green manure were significantly higher than from plots where cereals were being grown continuously. He also reported that the means of maize DM and grains yields from plots where legumes were grown for grains (unincorporated) were found to be higher than that of GM at mid – vegetative stage or maize after (tef) (Table 6). This showed that growing legumes for grain in rotation are more efficient in cycling nutrients than terminating early at vegetative stage as green manure or cereal after cereal. Pederson and Lauer (2003) also reported that soybean annually rotated with maize produced 17 % more grain yield than continuous maize. Sauerborn, et al; (2000) also recorded the lowest grain and straw yields of maize after another cereal, sorghum when grown as a preceding crop, within the context of soil functions and cropping system performance results from the study of Liebig, et al; (2002) also indicated that legume cereal sequence enhanced nutrient cycling efficiency.

3.0. CONCLUSION

The review has shown that the performance and yield of crops in the Savanna region of Nigeria can be maintained with green manure alone if it is available in sufficient quantity. It is a known fact that productivity of Savanna soils can be sustained under continuous land use if soil erosion is controlled and soil organic matter, soil physical and nutritional characteristics are maintained at a favourable level. It has also been revealed that leguminous crops such as mucuna, lablab, soybean, groundnuts, cowpea etc which cover the ground are always useful in protecting the soil micro – organisms and improves the water use efficiency. Legumes fix atmospheric – N through symbiosis and improves the soil fertility.

The quest for management practices that can solve increasing cost of fertilizers and its environmental problems has made the findings on incorporation of green manures, which is a biological N source and environmental friendly, of great benefits to resource – poor farmers. The findings also revealed that incorporation of legume fallow positively influenced grain yield and all the yield components of cereals (wheat, maize, sorghum and tef) studied. The studies also revealed that using green manure alone can give grain yield increases comparable to ones that can be obtained. The use of chemical fertilizers alone has not provided adequate measure in the maintenance of soil fertility for sustainable crop production. The inter cropping of leguminous crops and cereals gave maximum yields. This will make low inputs farmers to spend less on chemical fertilizers and have their soil improved by green manure. Therefore, adoption of green manure cropping system, which is environmentally friendly and a soil improver, will be the best option for sustainable crop performance and yield in the Northern Savanna.

Table 1: Effect of previous crops on wheat yield at Kadawa, Kano

Previous Crop	Wheat Yield (Kg / ha)		
	N0	N80	Mean
Sorghum	1629	3983	2806
Maize	2280	3902	3091
Cowpea	2805	4397	3601
Groundnut	3202	4148	3675

Source: Singh and Nnadi 1981.

Table 2: Effect of crop rotation on available nutrients content in soil at Kadawa, Kano (After harvest of 4 crops)

Rotation	Available nutrient (ppm)		
Rainy season – Dry season	N	P	K
Sorghum – wheat	18.8	9.7	142
Maize – wheat	27.3	10.8	161
Cowpea – wheat	35.2	11.3	170
Groundnut – wheat	36.4	11.2	169
Initial value in 1978	35.0	11.5	177

Source: Singh and Nnadi, 1981

Table 3: Influence of green manure on cob diameter (cm) and cob length (cm) of two maize varieties in 2005, 2006, 2007 and combined.

	Cob diameter (cm)				Cob length (cm)			
Treatment	2005	2006	2007	Combined	2005	2006	2007	Combined
Variety (V)								
SAMMAZ 12	3.91	4.23	3.86	4.00	12.4	13.7	12.4	12.8
SAMMAZ 27	3.80	4.18	3.86	3.96	12.8	13.5	12.1	12.8
SE ±	0.036	0.03	0.047	0.022	0.19	0.18	0.22	12.8
Green manure (G)								
Weedy fallow	3.72b	4.03b	3.63b	3.7ab	11.6b	12.3b	10.8b	11.5b
Mucuna	3.92a	4.25a	3.89a	4.02a	13.0a	13.9a	12.6a	13.2a
Lablab	3.95a	4.29a	3.98a	4.07a	13.1a	14.1a	13.1a	13.4a
Soybean	3.89a	4.26a	3.92a	4.02a	12.8a	14.0a	12.6a	13.1a
SE ±	0.038	0.032	0.041	0.021	0.01	0.21	0.22	0.11

Source: Adesoji, et al; 2013
Means followed by the same letter(s) within the same column and treatment are not significantly different at 5% level of probability using DMRT.

Table 4: Influence of green manure on number of rows cob and number of grains cob of two maize varieties in 2005, 2006, 2007 and combined.

	No of rows cob^{-1}				No. of grains cob^{-1}			
Treatment	2005	2006	2007	Combined	2005	2006	2007	Combined
SAMMAZ 12	14.8a	14.3a	14.3a	14.5a	420.5	438.8a	399.0	419.4a
SAMMAZ 27	14.0b	13.8b	13.9b	13.9b	398.7	416.2b	380.6	398.5b
SE ±	0.14	0.06	0.11	0.064	8.67	5.82	9.82	4.8
Green Manure (G)								
Weedy fallow	14.0b	13.5b	13.6b	13.7b	359.5b	370.9b	323.0b	351.1b
Mucuna	14.5a	14.4a	14.3a	14.4a	427.1a	445.4a	419.7a	430.7a
Lablab	14.5a	14.2a	14.4a	14.4a	430.6a	447.3a	422.0a	433.3a
Soybean	14.5a	14.2a	14.1a	14.3a	421.1a	446.4a	394.6a	420.7a
SE ±	0.15	0.17	0.17	0.09	8.0	9.43	9.62	5.22

Source: Adesoji, 2013.
Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 % level of probability using DMRT.

Table 5: Influence of green manure on grain yield (Kgha^{-1}) of two maize varieties in 2005, 2006, 2007 and combined.

	Grain yield (Kgha^{-1})			
Treatment	2005	2006	2007	Combined
Variety (V)				
SAMMAZ 12	1378	3432	1631	2147
SAMMAZ 27	1458	3187	1655	2100
SE ±	93.5	162.5	101	71
Green Manure (G)				
Weedy fallow	1086c	2058b	1090b	1411c
Mucuna	1613a	3677a	1857a	2382ab
Lablab	1543ab	3921a	1889a	2451a
Soybean	1432b	3581a	1736a	2249b
SE ±	59.7	130.2	85.7	55.6

Source: Adesoji, et al; 2013
Means followed by the same letter(s) within the same column and treatment are not significantly different at 5 % level of probability using DMRT.

Table 6: Effect of incorporation stage of green manure crops on total dry matter (DM) and grain yield (t ha^{-1}) of the subsequent maize crop.

Green manure cro (GMC)	Growth stage at incorporation (GSI)			Unincorporated	Mean*
	Mid - vegetative	Mid - flowering	Pod - setting		
	Total DM (t ha^{-1})				
Tef stubble	-	-	-	-	4.815b
Weed fallow	-	-	-	-	5.74b
Cowpea	6.65	8.37	10.59	6.30	7.955a
Black Dessie	4.92	6.03	7.25	3.98	5.545b
Awash Melka	6.03	5.70	7.49	5.65	6.224b
Soybean	5.99	6.83	8.82	8.21	7.463a
Mean*	5.881b	6.539ab	8.574a	6.035b	
	GMC	GSI	GMC X GSI		
LSD (0.01)	NS	2.091	NS		
(0.05)	1.777	-	NS		
	Total grain yield (t ha^{-1})				
Tef stubble	-	-	-	-	2.59c
Weed fallow	-	-	-	-	2.73bc
Cowpea	3.37	4.59	5.10	3.50	4.14a
Black Dessie	2.37	3.19	3.04	2.20	2.70bc
Awash Melka	3.09	3.42	3.62	2.54	3.17a – c
Soybean	3.40	3.05	4.60	4.75	3.95a
Mean*	3.055b	3.564ab	4.0909	3.249ab	
	GMC	GSI	GMC X GSI		
LSD (0.05)	0.99	0.98	NS		

Source: Tamiru, 2013.
*Means within a row or a column followed the same letter are not significantly different at the specified probability level.
DM = Dry matter, GMC = Green Manure Crop, GSI = Growth Stage at Incorporation; NS = Not Significant.

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