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Soybean treated plots residual effect on growth and yield performance of maize crop in Sudan and Guinea Savanna zones in Northern Nigeria

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ABSTRACT

An experiment was conducted in 2016 cropping season to evaluate residual effect of legumes experimental treatments on maize crop yield at the fields that were used for soybean the previous year at the two agroecological zones (Sudan savanna and Guinea savanna). After clearing and land preparations, experimental plots were demarcated. Plots size was 4 by 4.5m. There were seven treatments replicated four times, each for soybean and groundnut. Maize grain yield showed no significant difference between treatments in terms of maize yield). Result from Sudan savanna soybean field revealed no significant difference between treatments in terms of maize yield (P = 0.123). As for harvest index, there is significant difference (P =0.023) between treatments. On contrast result obtained from Guinea savanna soybean field showed that significant difference exists between treatments. nitrogen treatment recorded highest yield (2175 kg ha^{-1}). Result for major nutrients uptake in maize shoot showed no any significant difference between all the treatments observed in soybean fields at both Sudan savanna and Guinea savanna. From the finding of this study it can be concluded that. Result indicated that residual effect of leguminous crop treatments influenced yield performance of maize in Guinea savanna but no significant difference was observed in Sudan savanna.

Key words: Inoculants, soybean, maize crop, residual, cattle manure, legfume fix, alosca, sudan savanna, guinea savanna and nutrient uptake

1 Introduction

Maize was said to have originated from Central America. Archeologist revealed that the crop was domesticated in region of south western United States of America, Mexico and Central America. Columbus transported maize to Spain and later the crop spread to central Europe and eastern Europe. Maize is now widely spread to many countries like USA, China, Argentina, Brazil and Mexico (Anonymous, 2010). The United states is the largest world producer with 307 metric tons then China with 162 metric tons then Brazil with 54 metric tons, Argentina 15 metric tons and South Africa has 11 metric tons. In Africa Nigeria is the second largest producer After South Africa. In Nigeria Maize is grown widely from the Sudan to Guinea Savanna zones. It is important source of Protein, carbohydrate. It is used in Food processing industries, animal feeds and also for the manufacture of alcohol. Stalk is also being use in the paper industries (Akande *et al.*, 2006).

Maize is the second most important food crop in Nigeria. The study will portray to our local farmers the importance of nutrient cycling and management and also the sustenance of crop production with little application of inorganic fertilizer which is too costly for our poor farmers in Africa. Biological Nitrogen Fixation (BNF) through rhizobium inoculation has the potential ability to increase world food production especially in the sub-Saharan countries where hunger is eminent and prices of manufactured nitrogen fertilizers are known to be exorbitant (Kahindi and Karanja, 2009). It was on record that nitrogen loss through leaching and other means of nitrogen removal in maize in West African savanna is estimated to reached 36-80 kg N ha^{-1} per annum (Sanginga *et al.*, 2002). It was reported that Nigeria is the 10th largest producer of maize in the world and the largest in the whole of Africa (IITA, 2012). Maize production is progressively increasing in Nigeria as a result of improved varieties, it reaches a peak of 2196 kg ha-1 in 2009 before it progressively decline to 1850 and 1528 kg ha-1 in 2009 and 2010 respectively (Umar *et al.*, 2015).

For optimum yield to be attained plant nutrients must be available in sufficient quantity throughout the growing period (Unimke, Idehen, Mbre and Tagwai, 2016). This is a serious challenge in the African farming system. Researches have shown that Nitrogen (N) has been gradually depleted from the soils of West Africa and this pose a serious threat to food security in the region. However, many ways of increasing N supply (especially through usage of nitrogenous fertilizer and nitrogen-fixing plants) have been adapted and practiced in West African farming systems. Integration of legumes into cropping system of northern guinea savanna of Nigeria (NGSN) has been considered as important resources management for reduction of energy usage cost and pollution of inorganic fertilizer effect (Yusuf *et al*., 2009a). Despite this effort herbaceous legumes only contribute 40-70 kg N ha $^{-1}$ per season. This is just about 30% of the total Nitrogen applied as crop residue. Despite the demonstration by various extension agents of the importance of green manuring and incorporation of legume residue to the soil, the adoption of this practice by west African farmers is still limited (Sanginga, 2002). This experiment aimed at investigating the residual effects of soybean treated plots on subsequent maize yield in Sudan and Guinea savanna zones of Nigeria

2 Material and methods

2.1 Study area

The first location was Kano University of Science and Technology Research farm Sudan savanna in Kano State. Sudan savanna is located at latitude 11^{o} 37. 409 N and longitude 08^{o} 22. 994'E, situated about 481 meters above sea level. The second experimental location was Abubakar Tafawa Balewa University Research field. It was located on latitude 10°27. 985'N and longitude 9°49.768'E. The area is situated at about 666.5 m above sea level.

Land preparation was done separately for each plot to avoid contamination. Hoe was used to prepare seed beds for maize at individual plot. The maize the variety SAMMAZ14 obtained from IAR A.B.U. Zaria Nigeria was used for the residual effect experiment during 2016 cropping season. It was white maize seed. Seed was planted on the 23rd of July 2016 in Bagauda and on the 30th July in Gubi at the rate of 3 seeds per hole with spacing of 75 cm x 30 cm. Two weeks after emergence it was thinned to 2 plants per stand. First weeding was done four weeks after emergence with a simple hoe. Basal application of Nitrogen in form of urea was done for all the plots including the control at a rate of 20 kg ha $^{-1}$, and 30 kg ha $^{-1}$ four weeks after emergence and eight weeks after emergence respectively. No herbicides were applied in the two locations throughout the growing period.

2.2 Agronomic data collection Maize

2.2.1 Shoot biomass at 50% silking stage

Five plants shoot were harvested from the outer raws at middle silking stage, inserted in big envelops and taken to oven for drying at 60 ^{O}C for 72 hours. The shoots were used to determine N, P and K content in percentage basis.

2.2.3 Biomass yield

At harvest all Maize plants from the inner two rows of each plot were harvested and sun dried to constant weigh. The weight of the plant was then recorded.

2.2.4 Weight of Maize cob

Cob of individual plots were weighed at the harvest time to obtain their weight.

2.2.5 Grain yield per plot

Grain yield per plot was obtained by carefully removing the grains from cobs of individual plots by the use of manual grain remover and sun dried to constant moisture. The grains were then measured to get the yield per plot and then later converted to yield per hectare.

2.2.6 Weight of 100 seed

Weigh of 100 seed was obtained by picking 100 seeds randomly from each plot. This procedure was repeated three time and the mean weigh for each plot was recorded as the 100 seed weight per plot.

2.2.7 Harvest index

This is the ratio of economic portion to the non-economic portion of the plant. This was obtain by dividing the cob yield by the total biomass yield of each plot.

HI = CY/TY

Where : HI = harvest index

TY = total yield

CY= cob yield

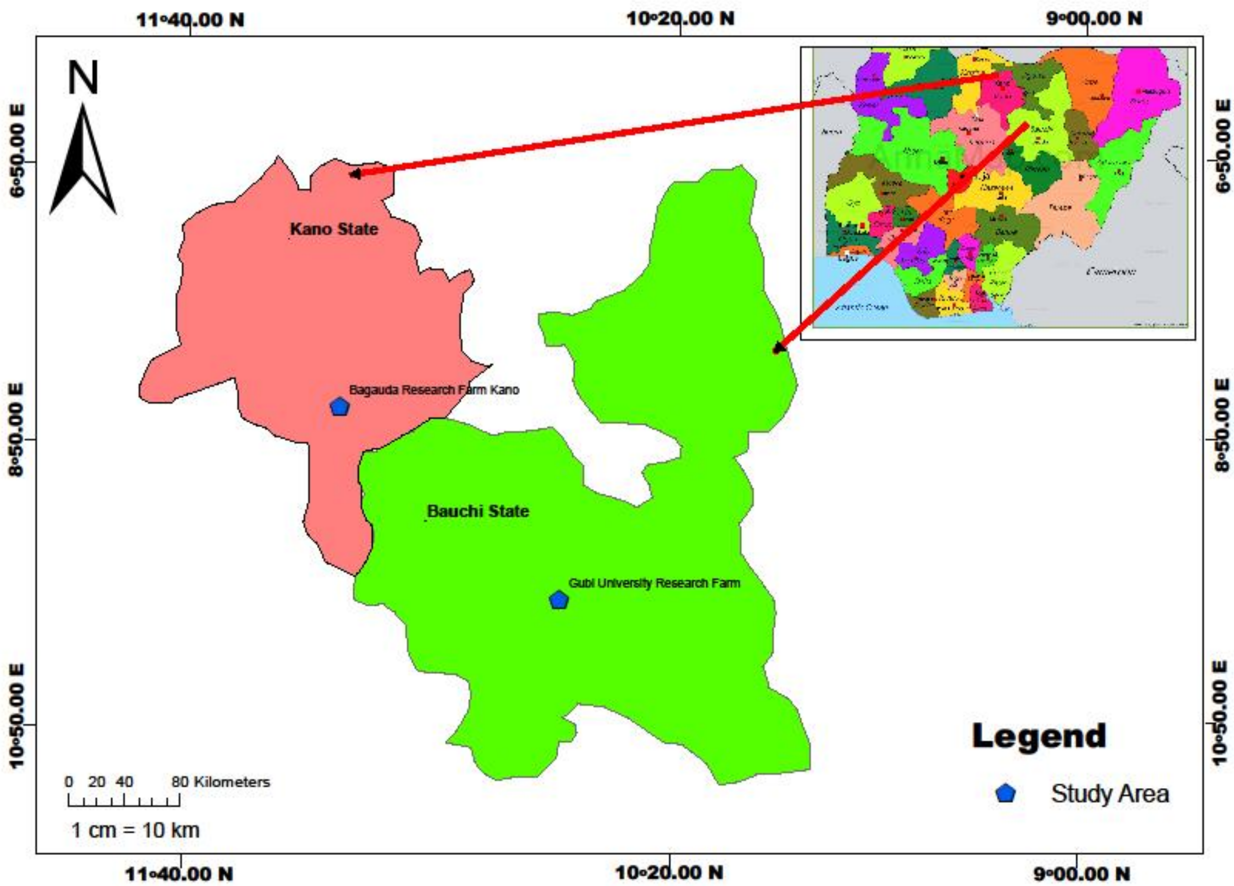

Figure 1. Location of the study area

3 Result

3.1 grain yield and harvest index

Table 1 shows results of grain yield and harvest index of maize grown on soybean experimental fields at the two study locations. Result from Sudan savanna soybean experimental field showed no significant differences between treatments in terms of maize grain yield (P = 0.123). Legume fix + cattle manure showed highest harvest index (0.45) which was not significantly different from cattle manure and nitrogen treatments. Maize grain yield in Guinea savanna showed that significant differences existed between treatments (P= 0.007). Nitrogen amended plots gave the highest maize yield (2175 kg ha^{-1}) which was not significantly different from alosca, legume fix + cattle manure and alosca + cattle manure amended plots. The control plot gave the least grain yield (1438 kg ha^{-1}) which was significantly different from all other treatments except cattle manure. Maize grain yield increments of 51.25, 44.85, 32.13, 29.48, 25.17 and 22.25% over the control were recorded for nitrogen, alosco, legume fix + cattle manure, alosca + cattle manure, legume fix and cattle manure respectively. However, harvest index among treatments at Guinea savanna showed no significant differences among the treatments (P = 0.321).

Table 1 Grain yield and harvest index of maize in soybean experimental fields

	Sudan savanna		**Guinea savanna**	
Treatments	Grain yield (kg ha^{-1})	Harvest index	Grain yield (kg ha^{-1})	Harvest index
Legume fix	2229	0.30 ^{c}	1800 ^{b}	0.43
Alosca	2042	0.35 ^{bc}	2083 ^{ab}	0.58
Nitrogen (50 kg N ha^{-1})	1812	0.39 ^{ab}	2175 ^{a}	0.54
Cattle manure	2292	0.38 ^{abc}	1758 ^{bc}	0.39
Legume fix + cattle manure	1604	0.45 ^{a}	1900 ^{ab}	0.51
Alosca + cattle manure	2438	0.30 ^{c}	1862 ^{ab}	0.67
Control	1821	0.36 ^{bc}	1438 ^{c}	0.33
F pr.	0.123	0.023	0.007	0.321
Lsd (5%)	NS	0.088	338.8	NS
CV (%)	2.8	2.8	6.3	14.7

* Means in the same column with the same superscript are not significantly different (P≥0.05).

3.2 Maize stover yield in soybean field at Sudan savanna and Guinea savanna

Results for maize stover yield at Sudan savanna soybean experimental fields was presented in table 2. Result showed that there was significant difference among treatments (P = 0.06). Generally, maize stover yield in Sudan savanna was higher than those in Guinea savanna. Legume fix recorded the highest maize stover yield (280 kg ha^{-1}) which only differed significantly from nitrogen which recorded the least (166 kg ha^{-1}). At Guinea savanna, maize stover yield was low compared to Sudan savanna. The control produced the highest maize stover (220 kg ha $^{-1}$), which was however not significantly different from cattle manure and legume fix. Alosca + cattle manure recorded the least stover yield (105 kg ha $^{-1}$) which was not significantly different from legume fix + cattle manure, nitrogen and alosca.

Table 2 Maize stover yield on soybean experimental fields

Treatments	Stover yield (kg ha^{-1})	
	Sudan savanna	Guinea savanna
Legume fix	280 ^{a}	180 ^{ab}
Alosca	223 ^{ab}	125 ^{bc}
Nitrogen (50 kg N ha^{-1})	166 ^{bc}	120 ^{bc}
Cattle manure	222 ^{ab}	204 ^{a}
Legume fix + cattle manure	219 ^{ab}	136 ^{bc}
Alosca + cattle manure	269 ^{a}	105 ^{c}
Control	252 ^{a}	220 ^{a}
F pr.	0.006	0.007
Lsd (5%)	80.9	64
CV (%)	5.1	11.1

* Means in the same column with the same superscript are not significantly different (P≥0.05).

3.3 Maize shoot N and P uptake

Table 3 – 4 shows results for shoot N and P uptake. Shoot N uptake for maize on Guinea savanna soybean fields were generally higher than Sudan savanna even though the difference was not significant. Maize phosphorus uptake at soybean experimental fields in both study locations showed similar trends.

Table 3 Maize shoot N uptake at soybean experimental fields

Treatments	Shoot N uptake (kg ha^{-1})	
	Sudan savanna	Guinea savanna
Legume fix	0.92	0.86
Alosca	0.63	0.97
Nitrogen (50 kg N ha^{-1})	0.60	0.79
Cattle manure	0.55	0.98
Legume fix + cattle manure	0.68	1.06
Alosca + cattle manure	0.78	1.00
Control	0.66	0.86
F pr.	0.48	0.75
Lsd (5%)	NS	NS
CV (%)	18.2	4.1

Table 4. Maize shoot P uptake at soybean experimental fields

Treatments	Shoot P uptake (kg ha^{-1})	
	Sudan savanna	Guinea savanna
Legume fix	0.08	0.09
Alosca	0.08	0.08
Nitrogen (50 kg N ha^{-1})	0.08	0.07
Cattle manure	0.07	0.08
Legume fix + cattle manure	0.08	0.08
Alosca + cattle manure	0.08	0.08
Control	0.06	0.07
F pr.	0.663	0.787
Lsd (5%)	NS	NS
CV (%)	13.8	14.5

4 Discussion

4.1 Grain yield and Harvest index of maize

Result from Sudan savanna soybean field revealed no significant difference between treatments in terms of maize yield (P = 0.123). As for harvest index, there is significant difference (P =0.023) between treatments. Legume fix + cattle manure showed highest harvest index (0.45) even though not significantly different with cattle manure and nitrogen treatments. This little variation could be due to improvement of soil structure and enhancement in moisture retention capacity of the soil due to cattle manure application. Another explanation could be because there was no any variation in the treatment application in all the plots during the residual experiment and the residues left from the preceding year might have been depleted or volatilize. On contrast result obtained from Guinea savanna soybean field showed that significant difference exists between treatments. nitrogen treatment recorded highest yield (2175 kg ha^{-1}). Here control recorded the least yield (1438 kg ha^{-1}). This could probably be due to competition between the native and introduced strains which could result in unpredictable result under field condition (Malusa *et al*., 2016).

Research have also shown that even in some situation where calculated N contribution of legumes was estimated to be negative yield had increased (Sanginga *et al*., 2002). It was expected for yield of proceeding crop to be increased under inoculated plots due to N contribution, but for such a desirable effect to occur the amount of N fixed return to the soil by legumes through their residue must be higher than the amount of soil N that was harvested along with crop and this is not always possible due to depletion, volatilization and harvest which resduced the N level of the soil (Giller and Wilson, 1991). Despite the fact that most of the nitrogen were harvested along with crop which could lead to the negative N balance, maize succeeding soybean and cowpea gave higher yield than when maize followed maize (Yusuf *et al*., 2009b). This could be the reason that average yield obtained was higher than the conventional yield obtained by farmers in the study area.

4.2 Maize stover at soybean fields at Sudan savanna and Guinea savanna

The result for maize stover yield at Sudan savanna soybean fields was presented in TABLE 2. Result showed that there was significant difference among treatments (P = 0.06). Legume fix produced highest stover yield (280 kg ha^{-1}), and nitrogen treated plot was the least (166 kg ha^{-1}). This could be because of short time effect of mineral fertilizer which could be lost through volatilization or leaching. However this result is contrary to the earlier finding by Nyalemegbe and Osakpa (2012) which stated that effect of leguminous crop residue does not influence dry weight of maize stover significantly. Generally, maize stover yield in Sudan savanna is higher than that in Guinea savanna location, and this could be due to location effects or variation of soils. Unexpectedly, at Guinea savanna soybean field the control plot treatment recorded higher values of maize stover than all other treatments. This could be due to competitive effect between introduced and native strains (Malusa *et al*., 2016).

4.3 Maize shoot major nutrients (N and P) uptake

Result for major nutrients uptake maize shoot under soybean at Sudan savanna and Guinea savanna locations surprisingly showed no any significant difference between all the treatments

both Sudan savanna and Guinea savanna. This could be due to single varietal test. Contrary to this Shehu *et al*. (2018) who observed three different yield nutrients yield while working with two varieties of maize in Northern Nigerian savanna. It was observed that N uptake value at Guinea savanna soybean field was higher than those of Sudan savanna, and this could probably be due to location and climatic variability. For maize P uptake at both soybean fields at Baguda and Guinea savanna, the results were almost similar no any significance difference was noticed. The lack of response could be due inability to make some amendments during the second-year experiments. Amusan *et al*. (2011) while working with soils on South Western Nigeria reported a positive response on yield of maize when treated with combination of legume residue, poultry manure and inorganic fertilizers.

It is imperative to note that one of the major limitations of the study during the second-year experiment was that no any distinct treatment was applied on the plots, so all the plots were treated equally including the control. Another limitation was that only one variety of maize (SAMMAZ 14) was used during the trial.

5 Conclusion

The residual effect experiment during the second year however showed inoculation influence over the control in some parameters under soybean field but in case of major nutrients uptake no any significant difference was observed in both soybean plots at the two locations. To fill knowledge gap in future research:

i Consider multiple locations, multi varietal trials and cover more areas to monitor the situation over consecutive growing seasons in future research to fill more gap of the study, since this study used only one variety of soybean for just one cropping season.

ii Farmers be encouraged to adopt the practice of legume maize production simultaneously since succeeding the legumes with maize will enjoy little residue effect since most of the residues will be lost before the following year through crop removal, leaching and volatilization.

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Disclosure of conflict of interest

The authors declare that there is no conflict of interests regarding the publication of this paper.

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