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PERFORMANCE OF MILLET IN IMPROVED MILLET-LEGUME STRIP CROPPING SYSTEMS AND TRADITIONAL MIXED CROPPING SYSTEM IN SUDAN SAVANNA OF NIGERIA

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ABSTRACT

The study area is characterized by high population density which leads to fragmentation of farmlands. The farmers continue to cultivate small farmlands using local varieties with low levels of technology resulting in depletion of soil nutrients with consequent reduction in yield per unit area. There is need to increase productivity through intensification of farming activities. As such, on-farm researcher-designed farmer-managed field trial was conducted in 2011 wet season to evaluate the best system(s) and optimum level of fertilization at which millet will perform better in mixture with legumes under improved strip cropping (4 X 4) systems and traditional farmer practice in selected 15 communities in Kano State, Nigeria. The experiment was analyzed as a randomized block design (RBD). The productivity of the systems was also compared on millet equivalent weight basis. The experiment consisted of seven (7) treatments involving millet-legume mixtures and 4 fertilizer application levels with number of farmers with each system as the replicates. The experiment was analyzed as a randomized block design (RBD) using analysis of variance and significantly different means were separated using Duncan's Multiple Range Test (DMRT). Generally, yields were low due to the low fertility status of the soils and that some demonstration farmers were reluctant in weeding plots receiving improved technologies. Nonetheless, Intercrop system significantly ($p \leq 0.01$) affected grain yield (on equivalent weight basis). It also significantly ($p \leq 0.05$) affected Stover yield of millet. Fertilizer level significantly ($p \leq 0.05$) affected panicle weight, 100-grain weight and grain yield of millet. Based on this, SOSAT C-88/Local cowpea and even the farmer practice (Local Millet/Local Groundnut) at recommended fertilization were recommended millet-legume systems in this region regarded as millet belt. Fertilizer manufacturers were also recommended to blend micronutrients (particularly Zn) for fertilizers meant for this zone.

Key words: improved strip cropping, farmer practice, fertilizer levels, equivalent weight

INTRODUCTION

Savanna zone is at the risk of declining agricultural production, parts of it have been severely affected by drought and food shortages in recent years (Ker, 1995). Apart from seasonal drought, the zone suffers from increasing population pressures, low soil fertility and farming system characterized by low level of technology. Millet, sorghum and maize are the major cereal crops whereas cowpea, groundnut and soybean are the most important legumes grown in the Nigerian savanna. Most of the production of these cereal crops comes in mixture of two or more of the cereals and legumes (Olabanji *et al.*, 2002 and Dugje, 2004). It is a common and dominant practice by most farmers in savanna zones of Nigeria to grow cereals and legumes in mixtures. In some cases, the crops are not grown on any definite row arrangement such that it makes some farming operation tedious or even impossible. Most of the farmers in the savanna of West Africa cultivate local variety of cowpea, millet, sorghum and groundnut in various intercropping systems with little or no purchased inputs and therefore yields are low (Mortimore *et al*., 1997; Singh and Ajeigbe, 2002) due to biotic and abiotic factors. The study area is characterized by high population density which leads to fragmentation of farmlands. The farmers continue to cultivate small farms using local varieties with low levels of technology year after year in an attempt to

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battle with their increased demand for food. This results in depletion of soil nutrients with consequent reduction in yield per unit area. In addition, farmers differ in their resource endowment (Legesse and Drake, 2005) and as such the quantity of input (e.g. fertilizer) applied are largely determined by farmers' purchasing power. Farmers have since realized the importance of mixed intercrop but are yet to realize the advantages the Strip cropping have over mixed intercrop vis-à-vis rotation of cereals with legumes. Strip cropping allows farmer to perform independent cultivation practices such as fertilizer application, pest control etc. in strips that are wide enough for such operations but narrow enough for the crops to interact agronomically. It is therefore the focus of this study to evaluate the performance of millet in improved millet-legume strip intercropping (compared to farmer practice) with the view of improving and sustaining soil and crop productivity of the savanna.

MATERIALS AND METHODS

This study was carried out in 15 communities across 3 local government areas (LGAs) of Kano State (Table 1). The experiment consisted of millet/legume intercrop and level of Fertilizer use. The experimental treatments were as follows:

Millet/legume strip intercrop

ML_1 = Millet (SOSAT C-88/Cowpea (IT90K-277-2)

ML_2 = Millet (SOSAT C-88/Cowpea (IT98K-205-8)

ML_3 = Millet (SOSAT C-88/Groundnut (SAMNUT 22)

Farmer's traditional mixed intercrop

ML_4 = Millet (SOSAT C-88/Local (farmer's) cowpea

ML_5 = Millet (SOSAT C-88/Local (farmer's) groundnut

ML_6 = Local (farmer's) millet/Local (farmer's) cowpea

ML_7 = Local (farmer's) millet/Local (farmer's) groundnut

Level of fertilizer use

Recommended fertilizer rates of 60 kg N ha^{-1}, 30 kg P_2O5 ha^{-1} and 30 kg K_2O ha^{-1} for millet was used to group the farmers in to four treatment groups:

FL_1 = 0 fertilizer use

FL_2 = > 0 but ≤ 50 % of the recommended rate

FL_3 = > 50 % but ≤ 75 of the recommended rate

FL_4 = > 75 % of the recommended rate.

Each community had 5 farmers with each having 3 plots of 1500m^2 each. Plot 1 and 3 had millet-legume intercrop arranged in alternate strips of 4 millet rows and 4 legume rows. The improved millet was SOSAT C-88. The legume was either cowpea (IT90K-277-2, IT98K-205-8 or groundnut (Samnut22). The middle plot was the farmer practice (where both or one of the component crops are/is local). The number of farmers with each treatment served as the replication, arranged in a randomized block design. Rows occupied by cereals had legumes in the previous year and vice versa. Seeds were sown at: millet 75cm × 25cm, thinned to 2 plants per hill; Cowpea/Groundnut 75cm x 25cm, thinned to 2 plants per hill. Harvesting was done manually at physiological maturity of the crops. Data were collected on panicle weight, 100-seed weight, grain yield and Stover yield. The productivity of the systems was calculated by determining the equivalent yield of millet in the intercrops. Equivalent yield was computed using Ey= (f x Ly) + My: where Ey= equivalent yield, Ly=legume yield, My=millet yield, f= factor = price of legume / price of millet. The collected data were subjected to analysis of variance as described by Snedecor and Cochran (1967) using general linear model in SAS (SAS, 2002). Soil samples were collected and analyzed for physical and chemical properties using standard procedures (Black, 1965; Bray and Kurtz, 1945).

RESULTS AND DISCUSSION

Generally, the soils had high sand fractions ranging from 715g kg^{-1} to 880g kg^{-1}, whereas the mean clay contents ranged from 94g kg^{-1} to 165g kg^{-1}. The mean soil pH values in water across the 15 communities were in moderately acidic range (5.6 – 6.0), except in Gurduba, Guruma and Zakirai communities(Table 2) which had strongly acidic soil reaction (5.0 – 5.5). Calcium was the dominant cation in all the soils, although the values were generally low (<5cmol/kg), with the lowest value in Gafasa and Ketawa communities. In all the communities, exchangeable Mg was low (<1.0 cmol kg^{-1}). The exchangeable K contents were generally within the low to moderate fertility classes with the highest values observed in soils from Ketawa. The exchangeable acidity (H and Al) of the soil across the communities ranged from 0.090 cmol kg^{-1} in Ketawa to 0.173 cmol kg^{-1} in Dabi and Guruba(Table 3). Similarly, the ECEC was generally very low (<5 cmol kg^{-1}). The available phosphorus (Bray 1) in some of the soils across these communities was in the low fertility class (<7 mg kg^{-1}), with lowest values in

Ajingi, Balare, Dabi, Gafasa, Gurduba therefore response to P fertilizer application is expected with most crops on these soils. Dadin Duniya, Gabasawa, Guruma, Joda had generally higher P values. The total nitrogen contents of the soils were generally very low (<1.0 g kg^{-1}) in all the communities (Table 4). This is not surprising considering the low levels of organic matter and the sandy nature of the soils which favour leaching of N. Similar to total N, the available sulphur content was also generally low, being above the critical limit (5.0 mg kg^{-1}) only at Ajingi, Dabi, Gafasa, Gurduba, Ketawa and Wangara. The analysis also revealed the organic carbon contents to be generally very low (< 4 g kg^{-1}). Zinc was low (< 1.0 mg kg^{-1}) in 33% of the communities but within moderate fertility class in the remaining 67% communities.

Effect of Intercrop System on Yield and Yield Components of Millet

Intercrop system did not affect yield and yield components of millet but, significantly ($p \leq 0.05$) affected only its equivalent and Stover yields (Tables 5 and 8). The system that provided the highest yield of millet was the mixture of local millet and local groundnut (1.26 t ha^{-1} millet equivalent yield) whereas SOSAT C-88/IT98K-205-8 provided the highest Stover yield (1.24 t ha^{-1}). This could be due to adaptability of the local cultivars to the local conditions. Moreover, this finding is in contrast with the work of Dugje (2004) who found similar mean grain yield (1.3 t ha^{-1}) from the combined yield of 1997 and 1998 from mixture of groundnut and SOSAT C-88 and thus concluded that SOSAT C-88 and groundnut was the most suitable mixture in the Sudan Savanna.

Effect of fertilizer level on yield and yield components of millet

Fertilizer level applied by demonstration farmers significantly influenced 100-grain yield, grain yield and millet equivalent yield per hectare (Tables 5 and 8). Millet 100-grain weight was only highest (1.03g) when >75% of fertilizer recommendation was met. Similarly, grain yield and equivalent yield of millet were highest (0.59-0.61 t ha^{-1} and 1.1 t ha^{-1}, respectively) beginning from when >50% of the recommended dose of fertilizer was added. It was not surprising considering the higher sand fractions of soils in the millet belt with accompanying low fertility status that called for optimum fertilization for millet to give high yield. Millet is virtually produced on native/residual fertility which results in negative soil nutrient balance and nutrients mining. Singh *et al*. (1983) estimated that 44, 22 and 15 kg ha^{-1} N, P_2O_5, and K_2O, respectively, are removed in the millet grain if the crop had been fertilized at the rates of 60: 30: 30 kg ha^{-1} of N, P_2O_5 and K_2O. Similarly, Kwari *et al*. (1995) showed that application of 60: 30: 30 kg ha^{-1} of N, P_2O_5 and K_2O produced grain yield of 1,603 kg ha^{-1} compared to 818 kg ha^{-1} from the plots that were not fertilized in Yobe State. Bationo *et al.* (1993) in their study on the effect of crop residue and fertilizer use on pearl millet in Niger over a four year period obtained a decline in yields of millet of control plots (initial yields were 280 kg grain ha^{-1} declining to 75 kg grain ha^{-1}) whereas yields of fertilizer plots were maintained at 800-1,000 kg ha^{-1}. Bationo and Mokwunye (1991) stressed the importance of the use of mineral fertilizers as to generally result in high yields of crops. However, the current high price of mineral fertilizer, exacerbated by distribution and marketing constraints makes it economically not feasible for resource poor farmers to rely solely on mineral fertilizer to replenish nutrients depleted by crops or other means (Kwari *et al*., 1998).

Effect of location on yield and yield components of millet

There were significant influences of location on yield and yield components of millet. The good performance of millet in terms of 100-grain yield, panicle weight, grain yield, millet equivalent yield and high Stover yields were obtained in Danja, Danzaki, Ketawa and Jogana communities. Millet yields of 0.57- 0.67 t ha^{-1} and equivalent yield of 1.3 t ha^{-1} were found. Olabanji *et al.* (2002) reported similar mean combined yield of millet (1.57 t ha^{-1}) from 50:50 proportion of millet/cowpea proportion. These low yields could be explained by the fact that soils of the millet growing zone of Nigeria are predominantly sandy, low in organic matter, effective cation exchange capacity and inherent low fertility (Ajayi *et al*., 1998). Farmers were found to have positive attitude of managing their farms appropriately with their local cultivars adapt very well to local conditions. In addition, correlation matrix (Table 10) revealed that pH, N, K, Zn and silt fraction of the soils correlated positively with millet grain yield indicating the sensitivity of millet to these soil properties; meaning that as each of these increases, millet grain yield increases. This is obvious considering their importance in growth and yield of millet and that silt, which is a medium fraction is important in retaining moisture and nutrients for crop use. As soil organic matter content declines, nutrients depleted by crops and leaching reduced base saturation, soil acidity increases, and this normally leads to decline in yield (Lombin, 1981). The highly significant positive correlation between millet grain yield and zinc content (Table 10) stressed the importance of this essential micronutrient. Cakmak (2008) reported that zinc deficiency is a well-documented problem in food crops causing decreased crop yields and nutritional quality. Application of Zn fertilizers or Zn-enriched NPK fertilizers offers a rapid solution to the problem. The significant negative correlation between exchangeable acidity and sand fraction indicated that increase in each of these two resulted in decreased millet grain yield.

Interaction between intercrop system and fertilizer level

Significant interaction between fertilizer level and intercrop system was observed on panicle weight, grain and equivalent yield of millet (Tables 6, 7 and 9). The heaviest panicle (67.9g) was obtained from local millet intercropped with local groundnut and received >50≤75% of fertilizer recommendation. Similarly, highest grain yields (0.99 and 0.90 t ha^{-1}) were obtained from millet in the LM/LG system fertilized with ≤75 % and >75 %, respectively, of recommended rate of fertilizer. This is to further support the adaptability and compatibility of local cultivars and that like improved varieties, the local millet responded well to high fertilizer requirements especially in this zone where nutrients are limiting owing to sandy nature of the soils and low organic carbon content. However, millet equivalent yield was highest in SOSAT C-88/LC system that received >0≤50 % fertilization (2.3 t ha^{-1}) probably due to the atmospheric nitrogen fixed by cowpea through symbiosis with nodule bacteria which is utilized by the millet (complementary effect).

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Table 1: Study Locations

	Local Government Areas (LGAs)		
	Ajingi	Gabasawa	Gezawa
Community	Ajingi	D/Duniya	Danja
	Balare	Gabasawa	Danzaki
	Dabi	Guru	Jogana
	Gafasa	Joda	Ketawa
	Gurduba	Zakirai	Wangara

Table 2: Mean particle size distribution and soil pH across the study sites.

Local Government	Community	Clay (g kg^{-1})	Silt (g kg^{-1})	Sand (g kg^{-1})	pH(water)
Ajingi	Ajingi	159±17.99	89±21.38	752±32.66	5.7±0.346
	Balare	156±15.11	120±42.76	723±38.04	5.6±0.180
	Dabi	162±12.65	123±54.28	715±48.02	5.7±0.361
	Gafasa	136±56.08	95±30.07	784±11.48	5.7±0.276
	Gurduba	142±17.89	66±17.89	792±12.65	5.5±0.137
Gabasawa	D/Duniya	94±20.00	26±17.89	880±22.80	5.6±0.141
	Gabasawa	94±14.14	58±39.72	847±31.27	5.6±0.209
	Guruma	119±25.07	39±22.25	841±34.36	5.4±0.198
	Joda	97±13.80	71±26.90	832±23.09	5.7±0.344
	Zakirai	94±16.33	68±32.07	837±27.60	5.5±0.244
Gezawa	Danja	145±35.46	65±26.90	789±45.89	5.8±0.354
	Danzaki	145±21.38	99±25.45	755±22.37	5.9±0.496
	Jogana	160±22.80	116±48.17	724±70.71	6.3±0.217
	Ketawa	161±10.35	98±32.07	742±37.70	5.9±0.236
	Wangara	165±34.17	102±47.21	733±47.41	5.9±0.605
	Mean	**135±35.93**	**83±41.47**	**783±63.79**	**5.7±0.361**

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Table 3: Exchangeable cations, effective cation exchange capacity and exchangeable acidity in soils across the study sites.

LGA	COMMUNITY	Exchangeable Cations (cmol (+) Kg^{-1}					
		Ca	Mg	K	Na	H+Al	ECEC
Ajingi	Ajingi	2.619±0.749	0.591±0.066	0.318±0.114	0.031±0.0007	0.160±0.033	3.719±0.963
	Balare	1.904±0.629	0.782±0.181	0.209±0.032	0.033±0.0004	0.149±0.038	3.077±0.880
	Dabi	2.22±0.680	0.847±0.131	0.267±0.068	0.032±0.0009	0.173±0.033	3.539±0.913
	Gafasa	1.875±0.589	0.868±0.088	0.219±0.029	0.034±0.0006	0.160±0.060	3.156±0.767
	Gurduba	2.361±0.974	0.579±0.045	0.356±0.098	0.031±0.0007	0.173±0.041	3.500±1.159
Gabasawa	D/Duniya	2.333±0.697	0.567±0.015	0.271±0.070	0.024±0.0019	0.136±0.046	3.331±0.830
	Gabasawa	2.037±0.439	0.574±0.024	0.258±0.096	0.024±0.0017	0.120±0.028	3.013±0.589
	Guruma	1.905±0.927	0.559±0.010	0.300±0.069	0.023±0.0024	0.137±0.039	2.924±1.047
	Joda	2.274±0.636	0.599±0.042	0.311±0.076	0.024±0.003	0.114±0.028	3.322±0.785
	Zakirai	1.905±0.629	0.623±0.031	0.264±0.099	0.025±0.003	0.109±0.038	2.926±0.800
Gezawa	Danja	1.905±0.629	0.571±0.022	0.357±0.031	0.035±0.0006	0.114±0.028	2.982±0.711
	Danzaki	2.262±0.407	0.595±0.039	0.328±0.024	0.035±0.0010	0.114±0.015	3.334±0.486
	Jogana	2.500±1.179	0.611±0.056	0.374±0.018	0.034±0.002	0.096±0.022	3.615±1.277
	Ketawa	1.875±0.863	0.587±0.031	0.412±0.039	0.034±0.004	0.090±0.028	2.586±0.965
	Wangara	2.024±0.813	0.587±0.029	0.374±0.028	0.036±0.002	0.126±0.036	3.147±0.908
	Mean	**2.112±0.718**	**0.637±0.121**	**0.307±0.086**	**0.030±0.005**	**0.131±0.0412**	**3.212±0.872**

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Table 4: Available phosphorus, sulphur, organic carbon, total nitrogen and Zinc contents of the soils

Local Government	Community	Phosphorus (mg kg^{-1})	Nitrogen ($g\ kg^{-1}$)	Sulphur (mg kg^{-1})	Organic carbon ($g\ kg^{-1}$)	Zn (mg kg^{-1})
Ajingi	Ajingi	3.173±1.615	0.540±0.097	5.151±0.819	3.705±1.727	0.844±0.314
	Balare	3.173±0.734	0.580±0.097	4.670±0.909	2.109±0.884	0.974±0.847
	Dabi	3.275±1.035	0.560±0.125	5.369±1.592	3.126±1.133	0.833±0.882
	Gafasa	2.669±1.159	0.490±0.075	6.370±2.764	2.594±0.319	1.023±1.107
	Gurduba	3.559±1.765	0.513±0.114	5.769±1.994	6.018±8.239	1.061±0.235
Gabasawa	D/Duniya	12.73±6.134	0.504±0.159	2.212±0.997	1.636±0.621	1.455±0.203
	Gabasawa	10.489±5.210	0.498±0.102	3.312±1.929	1.906±0.663	1.023±1.107
	Guruma	12.388±3.884	0.640±0.110	3.159±1.730	2.337±0.649	1.299±0.314
	Joda	11.106±4.548	0.580±0.170	2.129±1.796	1.967±0.268	1.494±0.344
	Zakirai	7.445±5.260	0.640±0.178	2.609±1.205	2.052±0.427	1.429±0.552
Gezawa	Danja	7.140±1.574	0.400±0.097	3.846±0.833	1.710±0.487	1.299±0.665
	Danzaki	5.675±0.879	0.540±0.097	4.258±0.757	2.024±0.481	0.974±0.665
	Jogana	5.639±1.106	0.644±0.254	4.231±0.789	3.671±2.095	0.818±0.932
	Ketawa	5.393±0.719	0.683±0.189	5.769±1.871	2.344±0.509	1.705±0.901
	Wangara	4.821±0.639	0.520±0.133	5.014±1.879	1.995±0.515	1.234±0.344
	Mean	**6.565±4.417**	**0.555±0.147**	**4.289±1.994**	**2.557±2.247**	**1.187±0.622**

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Table 5. Effect of intercrop system, fertilizer level and location on yield and yield attributes of local and improved components of millet intercropped with legumes, Kano State, 2011.

Treatment	100 grain weight (g)	Panicle Weight (g)	Threshing%	Grain Yield (kg ha^{-1})	Stover Yield (kg ha^{-1})
Intercrop system (IS)					
SOSAT/IT205	0.99	53.2	65.3	423	1244a
SOSAT/IT277	0.97	46.8	65.6	448	933.1ab
SOSAT/LC	0.91	40.0	76.9	471	701.1b
LM/LC	0.84	45.2	69.1	440	910.3ab
SOSAT/SAMNUT22	0.95	46.4	67.5	429	1033ab
SOSAT/LG	0.94	49.5	67.5	571	312.6c
LM/LG	0.99	54.9	71.5	623	905.3ab
SE±	0.026	1.45	1.15	31.5	36.30
Fertilizer level (FL)					
0	0.88b	46.4	67.7	323b	916.7
<50% of recommendation	0.90b	45.9	68.2	336b	944.0
<75% of recommendation	0.91b	45.8	65.6	592a	1036
>75% of recommendation	1.03a	49.2	66.8	613a	993
SE±	0.019	1.09	0.86	23.8	27.30
Location					
Ajingi	0.88def	47.2cd	76.3a	415bcd	947.5cd
Balare	1.09ab	61.9a	72.0ab	367bcd	1050bcd
D/Duniya	0.69g	32.9f	61.9ef	349cd	691.7ef
Dabi	0.84efg	42.7cde	64.6c-f	316d	976.7cd
Danja	1.19a	63.5a	74.7ab	651a	1132a-d
Danzaki	1.18a	65.8a	71.7abc	569a	1378a
Gabasawa	1.10ab	51.8bc	67.8b-e	372bcd	1201abc
Gafasa	0.80efg	44.2cde	63.5def	358.d	1089bcd
Gurduba	0.92c-f	45.9cd	67.3b-e	330d	873.2de
Guruma	1.07abc	58.9ab	70.1a-d	350cd	975.8cd
Joda	0.79fg	36.6ef	59.2f	546abc	927.0cd
Jogana	0.97bcd	36.4ef	66.4c-f	499a-d	1407a
Ketawa	0.94b-f	39.8def	64.5c-f	667a	1307ab
Wangara	0.96b-e	51.2bc	70.2a-d	429bcd	486.3f
Zakirai	0.71g	30.7f	61.9ef	525abc	909.9cd
SE±	0.034	2.12	1.68	46.1	53.20
IS X FL	NS	*	NS	*	NS

Means followed by same letter(s) in the same column are statistically similar (p>0.05) using DMRT. NS= Not significant * Significant at 0.05 level of probability.

Table 6. Interaction between intercrop system and quantity of fertilizer applied by demonstration farmers on panicle weigth of millet.

	Fertilizer level			
Intercrop system	0	≤50%	≤75%	>75%
SOSAT/IT205	-	47.9def	50.0cde	68.2
SOSAT/IT277	40.1hij	47.0efg	45.6efg	47.8def

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SOSAT/LC	30.8k	-	52.5cd	36.8j
LM/LC	50.6cde	39.0hij	43.2fgh	49.5cde
SOSAT/SAMNUT22	35.3jk	47.9def	43.9fgh	46.7efg
SOSAT/LG	-	53.2c	-	42.2ghi
LM/LG	-	37.7ij	67.9a	61.3b
SE±		2.89		

Means followed by same letter(s) in the same column are statistically similar (p>0.05) using DMRT.– Means no farmer with the said treatment applied the said level of fertilizer.

Table 7 . Interaction between intercrop system and quantity of fertilizer applied by demonstration farmers on grain yield of millet.

	Fertilizer level			
Intercrop system	0	≤50%	≤75%	>75%
SOSAT/IT205	440d-g	274gh	348fgh	584b-e
SOSAT/IT277	256gh	325fgh	673bc	650bc
SOSAT/LC	-	564b-e	-	424e-h
LM/LC	214h	360fgh	707b	515b-f
SOSAT/SAMNUT22	357fgh	317fgh	488c-f	632bcd
SOSAT/LG	-	923a	-	394e-h
LM/LG	-	325fgh	987a	903a
SE±		63.0		

Means followed by same letter(s) in the same column are statistically similar (p>0.05) using DMRT.– Means no farmer with the said treatment applied the said level of fertilizer.

Table 8. Effect of intercrop system, fertilizer level and location on the equivalent yield of local and improved components of millet intercropped with legumes, Kano State, 2011.

Treatment	Equivalent Yield (kg ha^{-1}).
Intercrop system (IS)	
SOSAT/IT205	837c
SOSAT/IT277	952bc
SOSAT/LC	1194ab
LM/LC	1082abc
SOSAT/SAMNUT22	866c
SOSAT/LG	857c
LM/LG	1259a
SE±	47.1
Fertilizer level (FL)	
0	762

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<50% of recommendation	884
<75% of recommendation	1056
>75% of recommendation	1101
SE±	35.7
Location (L)	
Ajingi	736c
Balare	983bc
D/Duniya	743c
Dabi	910bc
Danja	1307a
Danzaki	1318a
Gabasawa	753c
Gafasa	682c
Gurduba	887bc
Guruma	999bc
Joda	983bc
Jogana	978bc
Ketawa	1335a
Wangara	728c
Zakirai	1112ab
SE±	69.1
IS X FL	**

Means followed by same letter(s) in the same column are statistically similar (P≤0.05) using DMRT. ** Significant at 0.01 level of probability. Legume (cowpea and groundnut) yields in 2011 were converted in to millet equivalents using average market price (mean price of january-march, 2012) from local markets around; prices in Naira per kg of grains or kernel. Cowpea=N137.4; Groundnut =N112.1; Millet=N71.6. (Hudu, 2013).

Table 9. Interaction between intercrop system and quantity of fertilizer applied by demonstration farmers on equivalent yield of millet in kg ha^{-1}.

		Fertilizer level		
Intercrop system	0	≤50%	≤75%	>75%
SOSAT/IT205	895d-h	970d-g	542i	765e-i
SOSAT/IT277	731f-i	899d-h	1067de	1082de
SOSAT/LC	-	2298a	-	642hi
LM/LC	556i	1038def	1587b	1077de
SOSAT/SAMNUT22	784e-i	715ghi	881d-h	1175cd
SOSAT/LG	-	844e-i	-	864d-h
LM/LG	-	1070de	1606b	1407bc
SE±		1.6		

Means followed by same letter(s) in the same column are statistically similar (p>0.05) using DMRT.– Means no farmer with the said treatment applied the said level of fertilizer.

Table 10. Correlation matrix between soil properties and grain yield of component crops

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Soil properties	Millet	Cowpea	Groundnut
pH	0.188*	-0.226	0.047
Exc. Acidity	-0.275**	0.129	-0.025
K	0.221**	-0.206	-0.325*
Ca	-0.000	-0.005	-0.018
Mg	-0.265	-0.055	-0.036
P	0.008	-0.185	-0.045
S	0.114	-0.004	-0.005
Oc	0.075	-0.189	-0.107
N	0.205**	-0.029	0.097
Cu	0.008	0.106	-0.095
Mn	0.029	-0.053	-0.094
Zn	0.247**	-0.050	-0.034
Fe	0.029	0.105	0.056
Clay	0.119	0.238	-0.286*
Silt	0.237**	0.226	-0.055
Sand	-0.214**	-0.289	0.227

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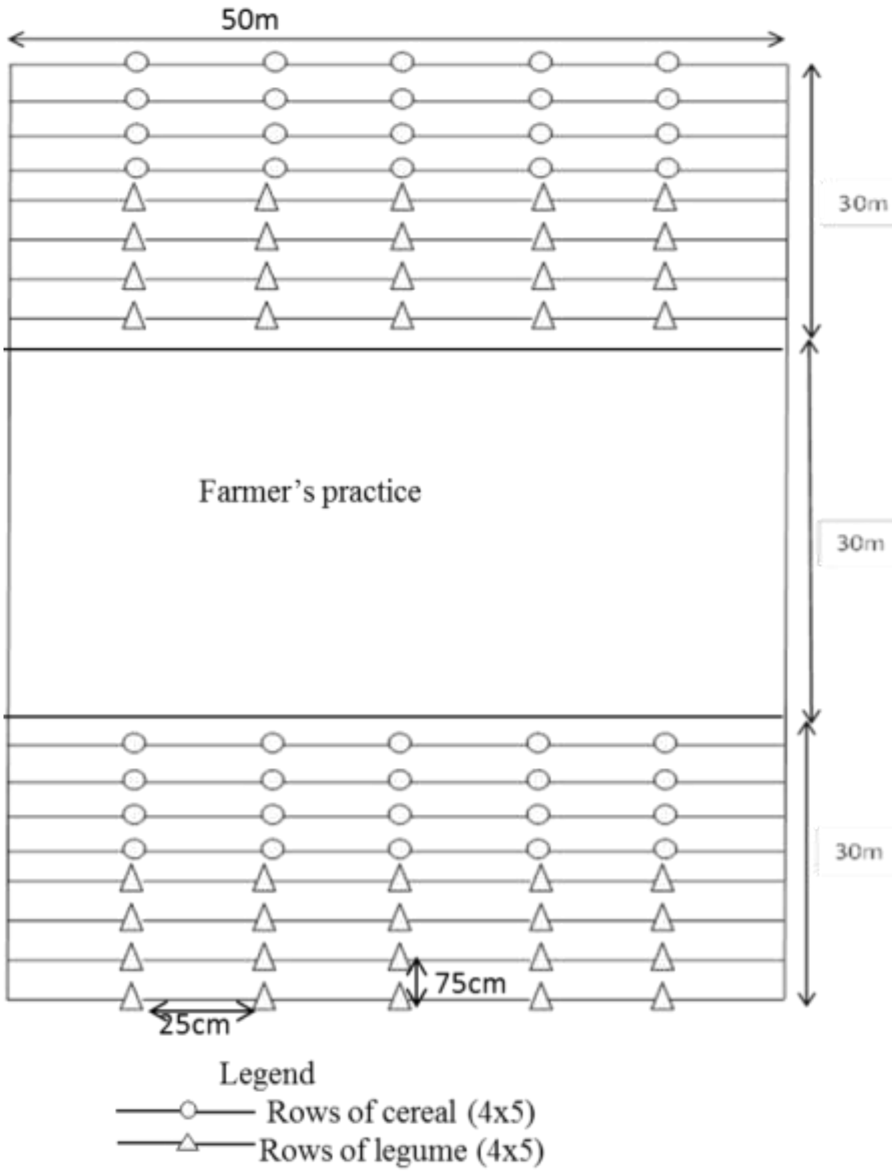

Fig.1 Description of Demonstration Plots