Seed management's influences on nodulation and yield of improved variety of soybean (*Glycine max*)

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Abstract— *A pot study was carried out on an improved soybean variety (TGX 1448-2E) to assess the effects of seed management on its nodulation and yield. The experiment was in factorial combinations with six replicates at the teaching and research farm of University of Abuja. The factors were 2 soils, 2 levels of phosphorus fertilizer (-P and + P), and 2 seed sources (farmer's and researcher's managed seeds). P was applied as triple superphosphate at 30 kg P ha^{-1}. Destructive sampling was done at 8 weeks after planting to record growth parameters and nodulation. At maturity, the number and weight of pods, weight of 50 seeds and total seed yield were recorded. The results showed that generally researchers' managed seeds showed a significantly higher mean values than farmers' managed seeds. The pod and total seed weight from researchers' seeds were 106.26 g and 52.43 g per plant respectively against the farmers' managed seed with pod weight of 80.23 g and total seed weight of 44.35 g per plant. P application influenced significantly the weight of nodules, pods and seeds per plant. This significant lower performance observed in farmers' managed seeds could have resulted from factors such poor seed handling or mix up during harvesting or storage, poor quality seed selection for planting.*

Keywords— Glycine max, seed management, phosphorus, nodulation, grain legume.

I. INTRODUCTION

Quality planting seeds are basic agricultural input needed for improved agricultural productivity (Pelmer, 2005). Presently, there is an expansion in cultivation area with a resultant increase in yield of soybean (Okogun *et al.,* 2004) and quality planting materials are needed to sustain this high yields. In line with this, many new bred soybean varieties have been released to national research centres and in collaboration with the national research systems (NARs). There is an increased adoption of these released varieties by farmers over local varieties. Farmers have, notably through their participation in on-farm trials, witnessed better performance and higher yield of improved varieties over local varieties.

TGX1448-2E is a high yielding soybean variety released by International Institute for Tropical Agriculture (IITA) with more than 1 t ha^{-1} over farmers' variety (Okogun *et al.,* 2004). They also have a high vegetative biomass, good ground coverage to control weeds and high N fixing ability and low in soil P tolerance level (Okogun *et al.,* 2004). It has a positive N-balance as residual N in the soil for the following crop in rotation (Sanginga *et al.,* 1997).

Seed accessibility and availability to farmers are determined by factors which include the crop breeding systems, institutional/organizational management and socio-economic condition of farmers.

In developing countries, the most important source of seed was farmers themselves. Majority of farmers do not replace their seeds annually with newly purchased seeds. They rely mainly on getting their seeds from informal channels which include farm saved seeds, seed exchanges among farmers or/and local grain/seed market. These channels contribute about 90-100 % of seed supply depending of the crop (Maredia *et al*., 1999). Most farmers did not have separate fields for seed production; hence they select the seeds for the next planting during harvesting, storage and/or even just before planting. These selected seeds are then kept either in sacks or in local storage structures till when they are needed. The farmers recycled seeds most time contains foreign materials such as stones, weed seeds, and insect infected seeds and this could affect the storability and thus quality of seeds (Parde *et al*., 2002). Furthermore, foreign materials among seeds can create non-uniform airflow resulting in poorly aerated environment and site for insect and mould growth (Ghosh and Jayas, 2010).

The distribution of improved seed varieties in developing countries through farmer-to-farmer seed exchange is an indication that there is more demand for improved varieties, but the participation of the formal sector is very limited. Therefore, this study was carried out to assess the effect of farmer's seed management on released soybean nodulation and yield potentials.

II. MATERIALS AND METHODS

2.1 Collection and preparation of soils samples

A potted experiment was carried out at the Teaching and Research Farm, University of Abuja, Nigeria. Soil samples were randomly taken at a depth of 0-15 cm with a soil auger to make a single composite sample for each of the locations namely; the Teaching and Research Farm of the University of Abuja and Sheda in Kwali LGA of Federal Capital. After a thorough mixing, subsamples were taken for the assessment of soil physical and chemical properties. Subsamples for the determination of pH, particle size, exchangeable cations and available phosphorus were air-dried ground and sieved to pass a 2 mm sieve while subsamples for organic carbon and total nitrogen determination were sieved to pass a 0.5 mm net after air drying. Thereafter, soils were weighed into 5 kg polyethene bags, making a total of 48 pots.

2.2. Experimental design and layout

The treatments were soils sources (2 levels), phosphorus fertilizer treatments (2 levels: with and without P fertilizer), and seed sources (farmer's managed and researcher's managed seeds). P source used was triple superphosphate (TSP) applied at 30 kg P ha^{-1}. The treatments were laid out as complete factorial combinations in a randomized completely block design and replicated six times.

Soybean variety (TGx 1448 – 2E) was the test crop. Five seeds were planted in each pot at 2 cm depth. They were thinned to 1 plant per pot 2 weeks after planting (WAP). Weeding was done regularly by hand pulling.

2.3. Data collection and analysis

Destructive sampling was done at 8 WAP on 3 replications. Parameters measured included shoot and root fresh weight, shoot and root dry weight, weight and number of nodules per plant. Harvested roots were carefully picked from the soil. Nodules were detached from the roots to access the nodule number and fresh weight per plant. Fresh shoot, roots and nodules were oven-dried at 80 ºC to a constant weight and their dry weights were recorded. At maturity, the total pods and seeds per plant were recorded. All the data collected were subjected to PROC GLM for the analysis of variance (ANOVA) in the Statistical Analysis System (SAS, 2008), version 9.2. Means were separated using the Duncan Multiple Range test at $P \leq 0.05$. The slice option in PROC MIXED was used to assess the single effect of the factor seed in the two and three-way interaction.

III. RESULTS AND DISCUSSION

3.1 Soil properties

The analysis results of the two soils used for the experiment show in Table 1 that soil from the University Research farm had a slightly alkaline pH of 7.6 while soil from Sheda in Kwali LGA was slightly acidic with a pH of 6.2. The soils are both sandy loam and generally low in nutrient content.

TABLE 1
CHEMICAL AND PHYSICAL CHARACTERISTICS OF SOILS FROM TWO SOURCES OF CENTRAL NIGERIA

Properties	Research farm	Sheda
pH (H_2O)	7.6	6.2
OC (g kg^{-1})	10.4	6.8
N (g kg^{-1})	0.83	0.51
Mehlich P (mgkg^{-1})	7.91	4
Ca (Cmol kg^{-1})	6.51	2.14
Mg (Cmol kg^{-1})	0.85	0.4
K (Cmol kg^{-1})	0.37	0.25
Na (Cmol kg^{-1})	0.38	0.08
Exch. Acidity (Cmol kg^{-1})	0.08	0.17
ECEC (Cmol kg^{-1})	8.19	3.05
Zn (mg kg^{-1})	8.55	5.41
Cu (mg kg^{-1})	3.41	1.66
Mn (mg kg^{-1})	104.51	59.6
Fe (mg kg^{-1})	174.42	179.83
Sand (g kg^{-1})	660	680
Silt (g kg^{-1})	150	190
Clay (g kg^{-1})	190	130
Textural class	Sandy loam	Sandy loam

3.2 Influence of soils, seed sources and fertilizers on plant parameters

The three factors main effects (soils, seeds and fertilizers) differently influenced the assessed parameters. The soil factor influenced significantly the number of nodules and pod weight but no significant difference was observed on shoot and nodule dry weight (Tables 2 and 3).

TABLE 2
EFFECT OF SOILS, SEED SOURCES AND FERTILIZERS ON SOYBEAN NODULATION

	Number of nodules		Fresh nodule weight (g plant^{-1})	Dry nodule weight (g plant^{-1})
Soils				
1	15.17 b		0.96 a	0.14 a
2	22.75 a		1.09 a	0.14 a
Seeds				
1	20.83 a		1.43 a	0.19 a
2	17.08 b		0.62 b	0.08 b
Fertilizers				
1	24.75 a		1.60 a	0.22 a
2	13.17 b		0.44 b	0.06 b

Values with the same letter in a column within each factor are not significantly different

TABLE 3
EFFECT OF SOILS, SEED SOURCES AND FERTILIZERS ON SOYBEAN DRY MATTER ACCUMULATION AND YIELD

	Number of pods		Dry shoot	Dry root	Pods	Total seed		50 seeds
			Weight (g plant^{-1})					weight (g)
Soils								
1	261.25 a		21.61 a	2.66 a	86.17 b	46.80 a		6.84 a
2	291.67 a		18.78 a	2.31 a	100.32 a	49.97 a		7.12 a
Seeds								
1	309.33 a		25.57 a	2.94 a	106.26 a	52.43 a		6.70 b
2	243.58 b		14.82 b	2.04 b	80.23 b	44.35 b		7.26 a
Fertilizers								
1	314.25 a		20.99 a	2.62 a	108.49 a	52.05 a		7.10 a
2	238.67 b		19.41 a	2.36 a	77.99 b	44.72 b		6.87 a

Values with the same letter in a column within each factor are not significantly different.

The seed source had significant effect on each soybean parameter measured in this experiment. Research managed seeds produced higher number of nodules and weight, shoot and root dry matter, number and dry weight of pods. However, the farmers' seed were heavier than research seed as shown by weight of 50 seeds. Otherwise, 8 over 9 parameters were highly increased by research managed seeds. This higher performance of breeders' managed seeds of TGx 1448-2E over farmers' seeds is an indication that though soybean is self-pollinated unlike Maize, it could still have varied quality of seeds when managed by farmers. This could have resulted from the different ways by which farmers acquire, manage, and transfer seeds among themselves. Most farmers do not have separate fields for seed production and select their seed during threshing, harvesting or even at planting.

The importance of P in soybean nodulation and production as observed by Kelly *et al*. (2001), Ogoke *et al*. (2006) and N'cho *et al*. (2013) was confirmed in this study. P fertilizer application increased significantly nodules number, fresh and dry weight, the number and dry weight of pod and total seed dry weight (52.04 g plant^{-1}).

3.3 Influence of the interaction between soil, seed sources and fertilizers on plant parameters

The result of the analysis of variance showed that the interaction effects between the different factors were significant (Table 4). Soil and fertilizer interaction showed significant effects on nodule number and total seed weight. The interaction

soil x seed did not influence the nodulation and the podding of soybean. In contrary, root dry weight and total seeds weight were differently influence by soil x seed interaction.

The 3- way interaction between soil, fertilizer application and seed sources had a significant effect on the dry shoot and nodule weight as well as on the pod and total seed weight. Nodule dry weight and total seed weight due the interaction are shown in Tables 4 and 5.

Comparing soil and fertilizer types separately for each seed source, the two-interaction including seeds was sliced by seed for total seed weight. As shown in table 6, soil and fertilizer types significantly differed in the interaction according to the seed source. Fertilizer effect as well, significantly affected the breeders' total seed weight.

TABLE 4

MEAN SQUARE FOR NODULATION AND DRY MATTER YIELD OF SOYBEAN IN CENTRAL NIGERIA'S SOILS

		Nodules (g plant^{-1})			Dry weight (g plant^{-1})	
Source	**Number**	**Fresh weight**	**Dry weight**		**Shoot**	**Root**
Soil (S)	345.04**	0.11 ns	0.00007 ns		48.17 ns	0.76 ns
Fertilizer (F)	805.04***	8.08***	0.14***		15.01 ns	0.41 ns
Seed (D)	84.38 ns	3.95***	0.07***		693.38**	4.92*
S * F	1395.38***	0.12 ns	0.003 ns		130.85 ns	0.56 ns
S * D	0.04 ns	0.17 ns	0.004 ns		197.11 ns	3.91*
F * D	273.38*	4.33***	0.06***		257.15*	2.71 ns
S * F * D	15.04 ns	0.76*	0.01*		610.24**	2.41 ns

TABLE 5

MEAN SQUARE FOR PODDING AND SEEDS YIELD OF SOYBEAN IN CENTRAL NIGERIA'S SOILS

	Pods		Seeds weight	
Source	**Number**	**Weight (g plant^{-1})**	**Total (g plant^{-1})**	**50 seeds (g)**
Soil (S)	5551.04 ns	1201.19*	60.20 ns	0.48 ns
Fertilizer (F)	34277.04**	5581.81***	322.59**	0.32 ns
Seed (D)	25938.37*	4064.58***	391.63**	1.94 ns
S * F	15251.04 ns	580.86 ns	182.11*	0.65 ns
S * D	1001.04 ns	59.38 ns	284.76**	1.75*
F * D	189570.38***	30300.69***	3454.32***	0.49 ns
S * F * D	11837.04 ns	2157.08**	1614.91***	1.09 ns

In developing countries, majority of the local farmers may not replace their seeds annually from certified seeds stores or research centres. Farmer would rather rely on acquiring their seeds through farmers to farmer transfer (seed recycling) or source from the local market.

TABLE 6

SOIL*SEED AND FERTILIZER*SEED EFFECTS SLICED BY SEED FOR TOTAL SEED AND NODULE DRY WEIGHT

Effects	Seed	Num DF	Den DF	F Value	Pr> F
Seed dry weight					
soil*seed	1	1	14	9.08	0.0093
soil*seed	2	1	14	1.24	0.2835
fertilizer*seed	1	1	14	88.12	<.0001
fertilizer *seed	2	1	14	24.93	0.0002
Nodule dry weight					
soil*seed	1	1	14	0.77	0.3948
soil*seed	2	1	14	1.30	0.2734
fertilizer *seed	1	1	14	100.49	<.0001
fertilizer *seed	2	1	14	4.03	0.0644

Home stored seed is the most important source of seed for most farmers and only a few of them obtained certified seed. Commercially certified bean seeds are known to costs 2 to 4 times of seeds obtained in local markets (Rubyogo *et al.*, 2007).

Extension agents need to improve on their interactions with local farmers to further stress on the implications of seed recycling among farmer on the yield of soybean. This could be achieved through the organization of demonstration and popularization programs to teach farmers about the improved certified seeds over recycling of seeds.

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