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Evaluation Of Somesoybean [*Glycine Max*(L.) Merrill] Genotypes For Yield And Agronomic Performance Under Low Ph Stressed Soils

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Abstract

Optimization of low pH soils for soybean production can best be achieved through screening and identification of soybean genotypes for adaptability. A total of twenty soybean genotypes (5 improved and 15 indigenous) were evaluated for yield potential and adaptability at different soil pH levels. Pot experiments were conducted in a completely randomized design(CRD) with three replications in 2015 and repeated in 2016 to determine the differential tolerance of 20 soybean genotypes to different soil pH levels. The pH levels were 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, and 7.0. At lower pH levels, agronomic and yieldperformance were severely restricted while at higher pH of 6.5 to 7.0 all the genotypes performed best. Major tolerance indicators such as plant height and root length discriminated the genotype,Vom as the most adapted and TGX1987-62F as the second best for adaptationto acid soil conditions as they gave higher seed yield than those with lower seed yield. Therefore, the utilization of these genotypes in breeding programs may likely lead to the development of new high-yielding and adaptive soybean to the hitherto under-utilized low pH and infertile soils of the tropics.

Keywords*: soybean, adaptability, pH, acid soil, genotype.*

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I. Introduction

Soybean (*Glycinemax* (L.) Merrill) is one of the most important and widely grown grain legumes in Sub-Saharan Africa because of its high protein (42%) and oil (20%) contents (Vaughan and Geissler, 2008). It is one crop that is rich in essential fatty acids and contains no cholesterol (Ogundipe and Weingarther, 1992), thus, its amino acids pattern is close to satisfying the needs of the human diet (Osho *et al*., 1995), thereby making it a very important crop for human and animal consumption. Soybean also has the capability for soil fertility improvement especially in the Guinea Savannas of Sub-Saharan Africa (Carsky *et al*., 1996; Yusuf *et al*., 2006), since it has the ability to fix approximately 300kg N per hectare of atmospheric nitrogen (Keyser and Li, 1992). As a legume when used in rotational cropping systems, it improves soil fertility thereby permitting farmers to use less fertilizer and reduce farm costs and it also have the ability to reduce striga infestations by promoting suicidal germination in cereal-based systems (IITA, 2013). In addition, soybean provide health benefits and as such are considered a strategic crop in fighting world’s food shortage and malnutrition problems. It has been reported that most food aids to displaced persons, refugees, malnourished people and HIV/AIDS patients are fortified with soybean derivatives (Thomas, 2004; Anon, 2013).Interest in soybean production in Sub-Saharan Africa especially in Nigeria has gained popularity, out-ranking cowpea (*Vigna unguiculata* L. Walp), because of its potential in supplying high quality protein (Akande *et al*; 2007) and the ability to sustain the world’s increasing demand for food and forage (Alghamdi, 2004).

Although soybean has a fairly wide range of adaptation involving a wide array of climatic, soil and growth conditions and it is mostly grown as a rain-fed crop (Fageria *et al.*, 1997), its production is still very low (<2.0 tons per ha) particularly among subsistence farmers of Sub-Saharan Africa compared to more than 2.7 tons per ha obtained in some developed countries (FAO,2013). Among the several production constraints responsible for the low productivity in many humid tropical regions of Sub-Saharan Africa is soil acidity and its attendant poor fertility. This is common when the soil pH drops below 5.0. At this level, aluminium is dissolved from clay minerals releasing Al3+ which is the most rhizotoxic form of the element (Hockenga *et al*; 2003) into the soil solution leading to low levels of macronutrients and worsening of the availability of micronutrients. Secondly, beneficial activities of some micro-organisms such as rhizobia and VA-mycorrhizae are reduced by soil acidity (Fageria and Baligar, 2003).However, under practical conditions of crop production, soil acidity involves many factors that adversely affect plant growth and development.

As soil acidity appear to be expanding due to some human activities, to improve crop production in acid soils, several strategies such as lime application have been pursued especially in developed countries. However, these soil amendments are not economically feasible for the subsistence farmers in the humid tropics as the price of lime is usually very high and the application should be done continuously (Uguru *et al*., 2012). This is because it is going to be recurring financial burden on the resource-poor farmers (Patiram, 2016). Similarly, applying large amounts of lime to highly weathered soils of the tropics always has harmful effects on soil structure as well as on available P and other micronutrients.However, an alternative strategy of developing aluminium tolerant genotypes of soybean adaptable to low pH soils remains the best option. In many crop species, a range of acid soil tolerance has been identified and selective breeding programs have produced crop varieties with increase tolerance to low pH soil conditions (Ojo *et al*; 2016). However, there is limited information regarding soybean tolerance to low soil pH of the high rainfall zones of Nigeria where there is high leaching and erosion of mineralized and applied nutrients. Therefore, the present study was initiated to evaluate the agronomic and yield performance of 20 soybean genotypes for adaptation to low pH soil conditions.

II. Materials and Methods

The materials for the experiment comprised five improved varieties of soybean obtained from the International Institute for Tropical Agriculture (IITA), Ibadan and fifteen local soybean cultivars collected from farmers in some selected soybean growing states of Nigeria. Hydrochloric acid (HCl) and calcium hydroxide ($Ca(OH_2)$) were used as amendment materials for the adjustment of different pH levels. The study was carried out at the Department of Crop Science Teaching and Research Farm, University of Nigeria, Nsukka July to November 2015 and repeated in 2016. The geographical location of the study site is Lat 06^o 52^1N; Long. 07^o 24^1E; Alt. 447.2 m. a. s. l.

Soil Analysis

Mechanical analysis of the soil was carried out by Bouycous hydrometer method as described by Gee and Bauder (1986). Soil pH was measured using Mclean (1982) method and organic carbon content was determined using weight combustion method as prescribed by Nelsen and Sommers (1982). Total nitrogen was determined using the micro kjedahl method as described by Bremmer and Mulvaney (1982) and available phosphorus was obtained according to Olsen and Sommers (1982). Cation Exchange Capacity (CEC) of the soil was determined by Ammonium method as prescribed by Thomas (1982).

Soil samples were collected from 0-20cm at random from different locations of the research farm and bulked to form a composite sample. Ten grammes of the composite sample were sieved (2mm), moistened to field capacity (FC) and analyzed in the laboratory to ascertain the amount of HCl and $Ca\ (OH)_2$ required for the amendment to obtain the different pH levels. Four kg of soil samples were collected at a depth of 0-20cm using soil auger and were weighed into 480 polythene bags after thoroughly mixing the soil with the required amount of $Ca\ (OH)_2$ to adjust the soil pH to 5.5, 6.0, 6.5 and 7.0 for the experiment, 1.2g, 2.3g, 3.2g and 4.4g, respectively were used. Similarly, to adjust some of the soil pH to 3.5, 4.0 and 4.5 for the experiment, 64cm, 36cmand $12cm^3$, respectively of HCl were uniformly mixed with the bagged soils. After the amendment, the bagged soils were moistened to 60% field capacity (FC) and covered for two days before sowing as recommended by Smith and Coull (1932). Initial pH of the soil was taken, at the beginning of the experiment (Table 1) and the pH of the potted soils were repeatedly determined at 2-weekly intervals for twelve weeks. The experiment was a factorial in completely randomized design (CRD) with three replications.

Data collection

The following data were collected on single plant basis, days to 50% flowering, days to 50% podding, days to 50% maturity, plant height (cm), number of leaves, number of branches, number of pods, pod weight (g), seed yield(g), root length (cm), number of nodules, number of lateral roots, fresh root weight (g), dry root weight (g) and 100 seed weight (g) per genotype.

Statistical Analysis

Data for the two years were analyzed separately using Genstat 10.3 DE package and significant means were separated by the least significant difference (LSD) at 50% level of probability. However, combined analysis of variance for the two years was performed using genstat-3 edition.

III. Results and discussion

Results of the physico-chemical properties of the experimental site (Table 2) revealed the texture of the soil as sandy clay loam with a pH of between 4.8 and 4.9. Indicating that the soil is strongly acidic in nature. The soil essential macro nutrients such as total N, K, organic matter and organic carbon were low meaning that the soil has a poor fertility status. However, available P was far higher than the established 7.0 mg/kg (Kang and

Nangju, 1983) as the critical soil available P for legumes such as cowpea. Exchangeable bases were however slightly higher in 2016 than 2015.

At the inception of the experiment, it was observed that soybean seeds sown at the initial soil pH of 3.5 did not germinate at all. This could be attributed to the high amount of hydrochloric acid used in amending the soil to that pH level. It has been reported (Blum,1996) that high hydrochloric in the soil interacts with organic matter establishing phenolic compounds that tend to inhibit germination in soybean. However, although there was germination at the initial soil pHof 4.0, it was poor and all the seedlings at that pH died within two weeks. This observation indicates that soybean seedling is more sensitive to soil acidity (Dechessa *et al*; 2010).

Combined analysis of variance (ANOVA) was performed for agronomic and yield traits of the soybean genotypes (Table 3) to determine the main effects of the different sources of variation (year (Y), genotype (G), environment (pH)) and their interactions. The analysis revealed that highly significant ($p<0.01$) differences was observedin days to 50% flowering, number of leaves and root length for year effect. However, significant difference ($p<0.05$) effect ofyear was observed in seed yield and 100 seed weight. On the other hand, non-significant effect of year was observed in traits such as plant height, number of branches, number of pods, pod weight number of nodules, fresh root weight and dry root weight, suggesting the uniformity of the experimental setups as was also observed by Ojo *et al.* (2016). The result also revealed non-significant effect of the interaction between the year and the environment (Y x pH) on most of the traits portraying the minimal effect of the changes in the soil pH on these traits. The highly significant ($p<0.\ 01$) and significant ($p<0.05$) effect of environment (pH) observed in all the traits is an indication that the pH had noticeable influence on the different genotypes outcome across the different levels. This observation is inconsonance with earlier reports of Cholin *et al*. (2010) and Jandong *et al.* (2011) where they all suggested the need of screening and identification of an ideal soil pH and genotype that can adapt to the test environment. The highly significant ($p<0.01$) genotypic effect observed for all the traits studied in this research is an indication of the presence of genotypic variabilityamong the genotypes with respect to their agronomic and yield performance which can be taken advantage of in selecting for low pH stressed soils of the humid tropics. Aduloju *et al.* (2009); Ojo *et al.* (2013) had earlier reported the existence of genetic variation among some soybean genotypes. Highly significant ($p<0.01$) variation among the genotype, environment (pH) and their interaction was observed for almost all the traits except number of nodules. Significant ($p<0.05$) interaction between the genotype and the environment (G x pH) observed in most of the traits revealed the differential performance of the genotypes under different pH levels. This observation validates the finding of Pereia *et al*. (2009) who reported significant genotype by environment (GxE) interaction in sixteen varieties of French beans.

Main effect of genotype and soil pH on agronomic traits of the twenty soybean genotypes are presented in Table 4. The results revealed that days to 50% flowering ranged from about 35 days in TGX1485-1D (an improved variety) to about 49 days in *Vom* (a farmer cultivar). Although there were significant ($p<0.05$) variation in number of days to 50% flowering among the genotypes, this could be attributed to divergent sources from where the seeds were obtained. However, genotypes such as *Andaha, Dadinkowa, Garkawa, Kagoro, Langtang, Lau* and TGX1987-62F were not statistically different from each other. The non-significant variation in the number of days to 50% flowering observed among the afore mentioned genotypes is in agreement with the finding of Ali *et al.* (2004) who reported non-significant variation in number of days to 50% flowering in some cowpea accessions. However, the interaction between soybean and soil pH revealed that low soil pH tends to extend the duration of the plant by delaying flower initiation especially at low soil pH. This observation is in agreement with the result of Adie and Ayda (2016) who also reported delay in flowering of some soybean genotypes at low soil pH.

The results also showed that genotypes varied in morphological traits such as plant height, number of leaves and number of branches which ranged from 22.16cm in TGX1485-1D to 40.93cm in *Vom,* 38.36 in TGX1485-1D to 70.91 in *Vom* and 2.78 in TGX1485-1D to 4.62 in *Vom*, respectively. However, *Gwantu,* TGX1987-10F and *Agbon kagoro* were statistically similar in height. Similarly, number of leaves were non-significant among genotypes such as *Agbon kagoro, Akwanga, Gwantu, Mararaba*,TGX1835-10E andTGX1448-2E. In a similar manner, most of the genotypes were of comparable number of branches except *Akwanga,Kagoro* and *Vom* that were significantly ($p<0.05$) different from each other. The non-significant differences in respect to number of branches among most of the genotypes indicates that no variability existed in this trait and so cannot be used as a selection index for adaptation to low soil pH. The significant variation observed in plant height and number of leaves in this study is an indication of abundant variability that exist in soybean genotypes for these traits that are amendable for selection. Variation in soybean morphological growth has also been reported by other researchers (Ugur *et al*; 2005; Azam *et al;* 2007). Although the root components varied among the different genotypes, this could be attributed to the genetic ingredients of the various genotypes. However, there was no statistical difference in root length among genotypes such as *Akwanga, Andaha, Garkawa, Gwantu, Langtang, Mararaba*, TGX1448-2E, TGX1987-62F and *Tiv local*. On the other hand, *Akwanga,* and *Tiv lal* were of the same number of lateral roots (3.61) that were not statistically different from those of *Agbon kagoro*, *Mararaba* and *Vom*. It was also observed that number of nodules were of comparable values among *Agbon kagoro*, *Ashuku*, *Garkawa*, *Langtang*, *Mangu* and TGX1485-1D. Fresh root weight varied significantly ($p<0.05$) within the genotypes with *Langtang* recording the highest value of 18.74g whereas, *Agbon kagoro*, *Ashuku*, *Dadinkowa*, TGX1835-10E, TGX1485-1D andTGX1987-62F were statistically similar. Although the genotype, *Langtang* also recorded the highest dry root weight of 4.78g, it did not differ significantly from the dry root weight of TGX1448-2E (4.23g).It has been reported by previous researchers (Adie and Ayda ; 2016 ; Wang *et al;*2010) that plant height and root length are some of the common morphological traits in identifying soybean genotypes that can adapt to low pH soils.

The interaction between soybean genotypes and soil pH on morphological traits showed that at low soil pH of 4.5 all the morphological traits were markedly smaller and as the soil acidity decreased, there was a noticeable increase in the morphological traits. The poor agronomic performance of the soybean genotypes at low soil pH may be ascribed to the significant effect of soil acidity on these traits as reported by Uguru *et al*. (2012).

Main effect of genotype and soil pH on yield and yield related traits of the twenty soybean genotypes (Table 5) showed that there were significant ($p<0.05$) variation in all the yield and yield related traits. Number of pods, pod weight and seed yield ranged from 22.62 to 99.97, 8.52g to 31.56gand 5.13g to 14.77g in*Tiv local* to *Vom*, respectively. However, non- significant difference was observed in these traits among genotypes such as *Garkawa*, *Gwantu*, *Kafanchan*, *Langtang*, *Mararaba*, TGX1448-2E and TGX1485-1D. The results also showed that 100 seed weight per genotype was comparable among all the genotypes except, *Vom* which differed significantly ($p<0.05$) from the rest. The interaction between soybean and soil pH on yield and yield components showed a significant variation among all the genotypes, revealing the presence of genotypic differences which if properly harnessed could be used in screening and selection for low pH soils. It was observed that raising the soil acidity tend to have a harmful effect on most of the soybean genotypes. As the soil acidity was decreased to 7.0, a noticeable reduction in yield and yield traits were observed suggesting that soybean grows best in a slightly acidic soils (pH 6.5) as earlier reported by Hans (2010). This observation was confirmed by Freeborn *et al*. (2001) who recorded the highest yield in soybean between the soil pH of 6.5 and 6.8. The decrease in yield and its component traits observed in this study at soil pH of 7.0, confirms the observation of Coutinho and Moreir (1986) who reported that sometimes the benefit of raising the soil pH is not obtained as decline in yield could still occur for reasons not fully understood. Although most of the improved varieties performed poorly in plant height and root length which are major indicators of adaptability to low soil pH, as demonstrated by the genotype, *Vom*, however, TGX1987-62F, TGX1485-1D, TGX1448-2E and TGX1835-10E performed impressively in terms of 100 seed weight. Therefore, these genotypes can be bred and developed into high-yielding varieties that can adapt to acid soils. It is appropriate to suggest that more improved and farmers' genotypes need to be screened in low soil pH zones of Nigeria to identify good candidates with promising potentials of high yielding in the hitherto under-low pH infertile soils.

IV. Conclusion

Soybean showed different tolerance to low pH stressed soils therefore screening of diverse genotypes from different agro-ecologies remains the best option for effective utilization of low pH soils. Among the twenty soybean genotypes evaluated at different pH levels, the genotype, *Vom*(farmer seed) out-performed all the others both in morphological traits and yielding potentials. However, most of the improved varieties equally gave high yield despite their poor morphological performance. Therefore, more trials at both research field and farmers' field need to be carried out for more precise information on selecting the best ones.

Conflicts of interest

The authors declare no conflict of interest

Table 1: Amount of lime and HCl added to the soil samples at the beginning of the experiment

pH	Amount of line or HCl added per 4kg soil to adjust the pH
7.0	4.4g $ca(OH)_2$
6.5	3.2g $ca(OH)_2$
6.0	2.3g $ca(OH)_2$
5.5	1.2g $ca(OH)_2$
5.0	No amendment
4.5	12cm^3 HCl
4.0	36cm^3 HCl
3.5	64cm^3 HCl

Table 2: Physical and chemical properties of the soil

Mechanical properties	2015	2016
Silt (%)	8.6	18.6
Clay (%)	29.6	30.9
Fine sand (%)	3.4	47.0
Coarse sand (%)	58.4	3.6
Texture	Sandy clay loam	Sandy clay loam
Chemical properties		
pH (H_2O)	4.9	4.8
Organic carbon (%)	1.048	1.064
Organic matter (%)	1.807	1.834
Total nitrogen (%)	0.1961	0.112
Available P (ppm)	45.700	42.0
Base saturation (%)	11.563	97.074
Exchangeable bases (meg/100/soil)		
Potassium	Trace	6.290
Sodium	Trace	0.171
Calcium	1.48	12.8
Magnesium	Nil	4.0
Exch. Acidity	1.2	2.0

Table 3: Combined analysis of variance of the effects of genotype, pH and theirinteractions in soybean

SV	DF	DF1	PH(cm)	NL	NB	NP	Pw (g)	SY(g)	RL(cm)	NLR	NN	FRW(g)	DRW(g)	100 seed wt (g)
Year (Y)	1	187.07**	16.87	218569.4**	0.56	1484.9	27.02	158.48*	10712.28**	2.57*	47.53	16.23	0.77	32.14*
Genotype (G)	19	478.23**	725.10**	2393.3**	5.68**	11030.7**	1079.60**	439.46**	582.26**	3.34**	380.27**	305.07**	20.63**	136.17**
PH	5	581.95**	1457.03**	11637.2**	56.59**	21708.0**	3215.76**	1342.78**	4516.75**	1.32*	3414.69**	825.91**	116.81**	116.89*
Y X G	19	55.59**	475.77**	1507.8**	1.50**	779.8*	120.69	62.10*	225.05**	1.49*	157.59**	175.74**	24.34**	79.54**
Y X pH	5	4.21	14.97	2915.6**	6.67**	148.8	58.00	7.59	38.34	1.49*	41.94	18.55	4.87*	21.93*
G x pH	95	297.16**	93.35**	463.1**	1.53**	836.8**	181.01**	72.71**	101.42**	1.04**	31.93	38.95**	3.33**	56.07**
Residual	480	2.81	12.76	165.2	0.62	40.3.9	85.07	31.04	39.39	0.64	26.94	16.41	1.83	9.41

* and ** = significant at 5% and 1%, respectively, SV= Source of variation, DF, = degree of freedom, DF1= days to 50% flowering, PH = plant height, NL = number of leaves, NB = number of branches, NP = number of pods, PW pod weight, SY = seed yield, RL = root length, NLR = Number of lateral roots, NN = number of nodules, FRW = fresh root weight, DRW = dry root weight, wt=weight

Table 4: Effects of genotype and soil pH on some agronomic years and yield traits of soybean in two (2015-2016)

Genotype	DF	PH (cm)	NL	NB	RL(cm)	NLR	NN	FRW(g)	DRW(g)
AGBON KAGORO	45.03	32.94	66.56	3.87	25.04	3.64	11.53	7.65	2.92
AKWANGA	44.06	34.49	62.09	2.92	34.85	3.61	14.23	10.50	3.31
ANDAHA	46.86	24.77	51.10	3.72	32.91	3.22	20.36	11.14	2.92
ASHUKU	37.97	25.35	47.13	3.31	23.71	2.97	11.64	7.65	1.93
DADINKOWA	46.06	27.30	56.54	3.78	31.53	3.31	15.06	7.70	2.44
GARKAWA	46.53	35.31	58.15	3.33	32.99	3.53	11.33	9.79	3.33
GWANTU	47.11	32.57	60.49	3.31	33.96	3.95	10.97	9.00	2.92
KAFANCHAN	44.78	28.68	48.69	3.69	30.43	2.78	9.23	6.50	2.25
KAGORO	46.83	29.31	53.41	4.03	30.28	3.31	12.39	14.26	3.98
LANGTANG	46.78	26.18	55.40	3.46	33.49	3.45	11.47	18.74	4.78
LAU	46.67	27.73	46.87	3.67	28.96	2.97	18.20	10.56	2.71
MANGU	39.78	22.74	48.82	3.17	25.41	2.87	11.34	8.66	2.89
MARARABA	48.87	36.45	61.42	3.61	32.39	3.72	10.42	10.85	3.35
TGX1835-10E	44.98	33.34	63.85	3.75	28.38	3.39	9.70	7.79	2.70
TGX1448-2E	44.28	34.96	61.25	3.42	34.81	3.36	13.45	12.14	4.23
TGX1987-10F	47.34	32.78	43.17	3.78	28.50	3.14	10.59	6.11	1.72
TGX1485-ID	34.84	22.16	38.36	2.78	27.78	2.87	11.20	7.43	2.68
TGX1987-62F	46.92	30.18	50.76	3.56	30.70	3.28	13.14	7.71	2.33
TIV LOCAL	44.92	25.98	57.35	3.48	33.47	3.61	7.00	10.19	3.62

VOM	49.08	40.93	70.91	4.62	38.59	3.78	17.84	11.84	3.32
LSD	1.09	1.85	7.51	0.52	4.12	0.53	3.41	2.51	0.85
PH									
3.5									
4.0									
4.5	46.59	23.43	36.44	2.36	20.14	1.80	4.80	5.71	1.54
5.0	46.45	30.29	52.69	3.33	28.06	3.05	9.02	8.37	2.42
5.5	46.06	31.34	55.97	3.55	30.58	3.33	10.98	9.14	2.72
6.0	45.75	32.56	59.21	3.81	33.89	3.65	15.00	11.55	3.49
6.5	45.68	32.69	62.44	4.26	37.53	4.06	19.08	12.89	4.30
7.0	45.77	31.48	62.80	4.12	34.30	4.03	16.88	11.40	3.64
LSD	0.60	1.29	4.12	0.28	2.26	0.29	1.86	1.37	0.47

DF= days to 50% flowering, PH = plant height, NL = number of leaves, NB = number of branches, RL = root length, NLR = Number of lateral roots, NN = number of nodules, FRW = fresh root weight, DRW = dry root weight,

Table 5: Effects of genotype and soil pH on yield and yield traits in two years (2015- 2016)

Genotype	NP	PW(g)	SY(g)	100 SW(g)
AGBON KAGORO	29.19	12.48	8.21	14.3
AKWANGA	30.43	11.33	6.86	14.8
ANDAHA	32.10	13.11	8.03	13.3
ASHUKU	29.60	11.65	7.46	14.3
DADINKOWA	38.12	14.50	8.85	14.5
GARKAWA	40.80	14.33	9.51	14.5
GWANTU	47.61	16.90	12.00	13.5
KAFANCHAN	40.74	15.25	9.18	13.8
KAGORO	60.29	28.12	11.51	15.3
LANGTANG	49.91	18.10	11.32	13.0
LAU	65.69	21.37	9.39	12.8
MANGU	56.22	20.46	12.75	13.3
MARARABA	49.48	15.79	10.48	14.0
TGX1835-10E	33.02	14.44	8.04	15.0
TGX1448-2E	44.62	17.78	11.80	15.0
TGX1987-10F	30.48	15.61	9.63	14.0
TGX1485-ID	46.87	17.82	9.70	15.0
TGX1987-62F	57.87	19.93	12.36	16.0
TIV LOCAL	22.62	8.52	5.13	15.0
VOM	99.97	8.56	4.77	11.3
LSD	13.12	6.04	3.58	4.32
PH				
3.5				
4.0				
4.5	23.05	8.42	5.21	11.93
5.0	37.08	13.75	8.48	12.01
5.5	43.06	16.72	10.49	12.32
6.0	52.50	19.67	11.96	12.46

6.5	58.71	22.65	14.38	13.00
7.0	56.15	20.26	13.08	12.65
LSD	7.17	3.31	1.96	3.41

NP = number of pods, PW= pod weight, SY = seed yield, SW=seed weight

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