EFFECT OF MOISTURE STRESS AND LOW PHOSPHORUS ON YIELD OF SOME SOYBEAN GENOTYPES

M.N. ISHAQ[1], R. RANAJIT[2] AND H. TEFERA[3]

1. National Cereals Research Institute, Badeggi, Niger State, Nigeria, E-mail:mnishaq2003@yahoo.com
2. International Institute for Tropical Agriculture, Ibadan, Nigeria
3. International Institute for Tropical Agriculture, Malawi

ABSTRACT

Soybean genotypes belonging to different maturity periods were planted under normal, nutrient (P) and moisture stress conditions in a combined design with three replications. The objective was to determine the effect of phosphorus and moisture stress on yield and yield components of soybean in order to select varieties that may be suitable for the northern guinea savannah zone of Nigeria. Soybean varieties differed in their response to nutrient and moisture stress. However there was more effect of moisture stress on yield and yield components than for Phosphorus stress. The effect of stress was more pronounced on number of pods per plants. Yield reduction of 88.95% was observed due to effect of moisture stress. Early maturing varieties had least percent yield reduction probably due to escape mechanism

KEYWORDS: Moisture stress, Phosphorus Soybean genotypes

INTRODUCTION

Soybean (*Glycine max* (L.) Merr) is a tropical legume that strives well in most of the agro-ecological zones of Nigeria. It is a potential grain legume crop in the guinea savannah zone of Nigeria. Soybeans have long been recognized as an excellent source of high-quality protein. The demand for soybean has continued to increase more than for other crops due to its high protein and oil content Sodangii, 2006). As a protein food, soybean is much better than other grain legumes. Due to its high protein and oil content the crop is of high nutritional value and can supplement the local diets especially where animal protein is expensive (Sodangi et al 2006). It is a crop that is gaining faster acceptability among farmers because of its nutritive value as a weaning food for infants and cheap source of protein for the privileged and the less privileged.

Nigeria's domestic production of soybeans is continuing to trend upwards, but still does not meet the growing demand. Despite this steady increase, domestic output continues to lag behind rising demand. Increased production is constrained by low yield levels resulting from biotic and abiotic stresses like disease, low nutrient and moisture deficit. Plant efficiency for nutrient uptake and utilization may improve yield potential in situations of soil nutrient stress, reducing plant demands for a given level of crop yield. The application of P improved biomass production, nodulation and P uptake and decreased root to shoot ratio, root length and surface area and P utilization efficiency (Burriro et al, 2002). Differences in grain yield among soybean cultivars for phosphorus (P) have been reported by De Mooy et al. (1973). Moisture stress at any of the growth stage of soybean will reduce grain yield. However blooming, pod formation, and pod fill are the most critical stages for water stress, which caused high reductions in number of pods and grains per plant, seed weight and yield. The soil moisture stress at early vegetative growth also caused reduced height and plant population (Foroud et al, 1992). Moisture stress reduced the number of nodes/plant and, when it occurred during the reproductive stage, reduced seed weight. It also affects the nodal distribution of yield components (Mahmood et al, 1999).

The objective of this research therefore was to select soybean genotypes in relation to low Phosphorus and soil moisture stress in southern guinea savannah of Nigeria.

MATERIALS AND METHODS

Nineteen varieties (19) of soya bean including a check entry TGx1019-2EN were planted on two different dates; 10th July 2008 for the early planting and 11th September 2008 for the late planting (drought screening). Combined design with 3 replications was used where first planting was done for Phosphorus applied and no phosphorus applied plots and second planting was delayed until two months after the first planting (i.e. 11th September,2008) for moisture stress screening. Seed were drilled in to 5mx4m rows and later thinned 3 weeks after planting to a spacing of 5cm between stands on rows that are spaced 50cm apart. Supper phosphate fertilizer (SSP) was applied at the rate of 30kg/ha only to the control plots i.e. non stress plots. Soil analysis done prior to planting of soybean shows that only 12ppm of P was available in the soil. Normal weeding and other agronomic practices were done as per recommended practices of soybean production of National Cereals Research Institute Badeggi. The following data were taken on 5 plants per plot: days to 50% flowering, days to maturity, number of pods par plants, nodulation rate, number of plants harvested, 300 seed weight(g/plot), fodder weight (kg/plot), height of plant at harvest (cm), height of lowest pod (cm), yield per plot (kg/ha). The data was subjected to analysis of variance and Stress Susceptibility Index (SSI) and Percent Yield Reduction (PYR) were calculated as follows:

Stress Susceptibility Index (SSI) = (1- (Y_s/Y_p) as suggested by Bouman, B.A.M. and T.P. Tuong, (2001). and

PYR = Y_p-Y_s/Y_p

In above relationships, Y_p and Y_s are grain yield of all varieties in non-stress and stress condition respectively.

RESULTS AND DISCUSSION

Varieties showed differences in yield performance under normal (non-stress) and stress conditions. Under normal condition where P was applied at recommended dose of 30kg/ha (Table1), TGx1971-1F had the highest yield followed by TGx1937-1F and then TGx1910-14F; while the lowest yield was observed in TGx1835-10E. Under Phosphorus stress condition (Table 2) TGx1937-1F had the highest yield followed by TGx1971-1F and TGx1908-8F. TGx1835-10E also had the lowest yield under zero phosphorus application. In moisture stress condition, (Table3) all varieties performed poorly compared to normal and phosphorus stress conditions. However, TGx1908 had the highest yield followed by TGx1835-10E. There was not much effect of phosphorus stress on yield and yield components of soybean but the effect was severe under moisture stress condition. According to Mahmood et al (1999) water stress reduced pods and grains per plant, and seed weight. Increase in phosphorus also augmented number of pods and grains per plant as well as seed weight. Moisture stress at any growth stage of crop reduced grain yield (Ishaq and Olaoye, 2008). However blooming, pod formation, and pod fill for soybean are the most critical stages for water stress, which caused high reductions in number of pods and grains per plant, seed weight and yield (Foroud, *et al*, 1993). The effect of moisture stress was more pronounce on number of pods per plants, number of plants harvested and seed weight (Table3). The seed-filling period was shortened by the severe stress treatment. The seed filling period was more sensitive to moisture stress hence no variety had up to 300 seeds to be able to that data like in Table 1 and 2(Table3). The effect of moisture stress on the duration of seed fill may be one way that stress reduces soybean yield. Soil moisture stress at early vegetative growth also caused reduced height and plant population (Mahmood *et al*, 1999). Some studies have shown that the vegetative growth stages are less sensitive to water deficit than reproductive stages (Foroud *et al*, 1993). Others indicated that water deficit during flowering had little effect on yield, whereas the effect during pod elongation and seed enlargement was significant (Robert and Edward, 2002)

Table 1: Mean Performance of Elite Soybean varieties for low P and drought tolerant screening (A: P applied)

S/no	Variety	Days to 50% flowng	Days to maturity	No of pods /plant	No of plants harv	300 seed weight (g/plot)	Fodder weight (kg/plot)	Plot yield (kg/plot)	Height at harv (cm)	Height of lowest pod (cm)	Nodulation rate
1	TGx1954-1F	38.0	96.7	48.3	91.3	49.4	0.50	0.75	60.5	10.3	1.7
2	TGx1440-1E	41.0	101.0	59.3	84.0	50.4	0.52	0.71	68.0	10.0	1.3
3	TGx1910-14F	38.0	97.0	63.7	71.0	36.4	0.73	0.90	54.6	10.0	1.3
4	TGx1908-8F	37.3	88.7	43.7	81.0	52.3	0.52	0.71	47.2	8.7	1.0
5	TGx1904-6F	37.0	86.3	46.7	51.3	45.4	0.35	0. 41	58.8	8.0	2.3
6	TGx1835-10E	37.0	95.3	23.7	23.7	32.4	0.22	0.18	62.5	7.7	1.7
7	TGx1951-4F	36.0	97.7	73.0	71.0	43.2	0.57	0.68	67.1	10.3	2.7
8	TGx1740-4F	36.7	88.7	40.3	42.7	33.9	0.10	0.31	50.1	6.7	1.3
9	TGx1485-1D	42.0	85.0	54.7	81.0	50.2	0.73	0.87	43. 1	9.7	2.7
10	TGx1844-4E	40.0	103.0	70.3	83.7	46.5	0.63	0.88	37.4	7.7	2.3
11	TGx1937-1F	41.0	103.7	70.0	93.0	43.3	0.80	0.95	54.4	8.0	1.0
12	TGx1448-2E	41.3	100.0	70.3	74.0	33.7	0.48	0.77	51.8	9.7	2.7
13	TGx195-3F	41.0	103.7	60.3	58.0	36.9	0.37	0.65	56. 6	6.7	1.7
14	TGx1961-1F	38.0	102.3	58.0	81.7	40.5	0.60	0.82	54.7	12.0	1.0
15	TGx1965-7F	40.3	96.7	47.7	50.3	44.2	0.37	0.57	49.6	10.3	1.0
16	TGx1830-20E	37.0	106.0	47.0	77.0	50.9	0.67	0.88	54.3	9.0	1.7
17	TGx1956-1F	39.0	91.3	81.3	67.3	49.0	0.62	0.81	59.5	8.0	1.7
18	TGx1971-1F	37.0	97.0	96.3	89.0	46.6	0.73	1.10	45.9	7.7	2.3
19	TGx1019-2EN	37.0	89.0	39.7	54.3	37.0	0.20	0.39	44.7	10.7	1.0
	CV	15.5	17.6	38.0	21.5	24.0	30.2	25.1	26.4	28.7	31.2
	SE	7.9	9.8	12.7	14.9	11.8	8.9	12.2	15.1	14.6	3.4

Table 2: Mean Performance of Elite Soybean varieties for low P and drought tolerant screening (B: no P applied)

S/ no	Variety	Days to 50% flowng	Days to maturity	No of pods /plant	No of plants harv	300 seed weight (g/plot)	Fodder weight (kg/plot)	Plot yield (kg/plot)	Height at harv (cm)	Height of lowest pod (cm)	Nodulation rate
1	TGx1954-1F	38	97.3	60.0	70.3	50.0	0.53	0.51	34.0	10.3	1.3
2	TGx1440-1E	42	101.3	41.7	82.0	48.8	0.86	0.48	28.7	8.7	1.7
3	TGx1910-14F	38	96.3	49.7	63.7	35.7	0.74	0.42	43.7	9.0	1.3
4	TGx1908-8F	38	88.0	42.7	52.0	53.2	0.74	0.68	31.3	10.0	1.3
5	TGx1904-6F	38	86.0	55.0	52.0	44.4	0.33	0.31	41.7	8.3	1.3
6	TGx1835-10E	38	96.7	51.7	26.7	33.0	0.12	0.16	39.0	9.3	1.3
7	TGx1951-4F	38	96.7	60.0	64.0	43.8	0.51	0.57	44.0	9.0	1.3
8	TGx1740-4F	37	88.7	48.7	91.3	36.5	0.33	0.28	40.7	11.3	1.0
9	TGx1485-1D	37	90.7	67.0	55.0	49.9	0.43	0.50	50.7	6.7	1.3
10	TGx1844-4E	42	105.3	45.0	50.0	46.7	0.83	0.66	37.3	7.0	1.7
11	TGx1937-1F	41	103.3	36.0	44.3	43.2	0.81	0.71	41.7	10.7	1.3
12	TGx1448-2E	42	99.7	49.3	80.7	33.7	0.80	0.60	54.3	8.0	1.3
13	TGx1935-3F	41	107.0	43.7	53.7	36.9	0.68	0.40	42.3	8.3	1.7
14	TGx1961-1F	41	102.3	56.7	47.3	41.1	0.59	0.33	48.7	10.7	1.3
15	TGx1965-7F	38	95.3	41.7	60.7	43.9	0.63	0.34	51.3	9.3	1.3
16	TGx1830-20E	41	101.0	72.3	45.0	50.6	0.58	0.46	48.0	8.0	1.3
17	TGx1956-1F	38	92.3	48.3	69.3	49.5	0.73	0.58	37.3	8.0	1.3
18	TGx1971-1F	40	96.0	64.7	37.3	46.1	0.53	0.68	45.7	10.3	1.7
19	TGx1019-2EN	37	92.3	47.3	46.7	37.0	0.42	0.33	37.0	7.0	1.3
	CV	12.5	21.8	12.9	24.4	24.5	31.1	15.3	31.5	15.6	23.4
	SE	6.9	12.1	3.8	14.7	11.4	13.9	10.5	17.2	1.8	19.6

Table 3: Mean Performance of Elite Soybean varieties for low P and drought tolerant screening (C: moisture stressed applied)

S/No	Variety	Days to 50% flowng	Days to Maturity	No of pods /Plant	No of plants harv	300 seed weight (g/plot)	Fodder weight (g/plot)	Plot yield (Kg/plot)	Height at harv (cm)	Height of lowest pod (cm)	Nodulation rate
1	TGx 1954-1F	36.3	96.3	17.7	27.7	-	61.7	0.17	86.0	11.0	1.7
2	TGx1440-1E	40.0	98.0	21.7	39.0	-	77.0	0.22	111.0	10.0	1.0
3	TGx1910-14F	37.3	94.0	23.7	25.0	-	65.5	0.31	91.4	9.3	1.3
4	TGx1908-8F	37.3	87.7	14.3	26.0	-	46.9	0.38	71.7	10.3	1.3
5	TGx1904-6F	37.0	87.0	18.3	34.0	-	51.8	0.14	78.3	8.7	1.7
6	TGx1835-10E	38.0	91.7	21.3	38.0	-	53. 4	0.15	87.5	8.7	1.0
7	TGx1951-4F	37.3	97.0	30.0	51.0	-	52.9	0.12	75.8	9.7	1.0
8	TGx1740-4F	36.7	89.0	27.3	33.3	-	60.1	0.16	88.6	9.0	1.7
9	TGx1485-1D	36.3	85.7	32.3	41.0	-	68.5	0.14	95.0	9.3	1.3
10	TGx1844-4E	40.3	101.7	26.3	50.0	-	60.9	0.15	78.4	10.3	1.0
11	TGx1937-1F	40.0	102.0	21.7	42.3	-	56.7	0.19	92.9	11.7	1.0
12	TGx1448-2E	41.0	98.7	18.3	47.3	-	66.9	0.24	92.1	10.0	1.0
13	TGx1935-3F	40.0	101.0	22.0	35.7	-	86.2	0.13	130.3	9.0	1.0
14	TGx1961-1F	40.3	101.3	20.0	32.7	-	60.5	0.15	78.2	8.0	1.7
15	TGx1965-7F	37.3	95.0	17.7	29.7	-	69.8	0.15	97.4	9.3	1.0
16	TGx1830-20E	40.3	102.7	22.0	41.0	-	56.2	0.27	87.7	9.3	1.0
17	TGx1956-1F	37.7	95.0	24.0	50.0	-	81.4	0.12	126.7	9.0	1.3
18	TGx1971-1F	38.0	95.0	32.3	52.3	-	84.4	0.15	118.7	9.0	1.7
19	TGx1019-2EN	35. 7	86.7	20.0	38.0	-	53.8	0.14	70.4	9.0	1.0
	CV	27.0	19.0	15.5		-	23.8	16.8	15.8	15.3	32.7
	SE	16.2	10.3	2.4	12.2	-	8.8	9.6	8.5	7.1	0.2

Table 4 shows the Stress Susceptibility Index and Percent Yield Reduction of the varieties. It was observed that high yielding varieties were more susceptible to stress than low yielders. Higher yield losses due moisture stress were more pronounce than yield loss due to p-stress. Yield loss due to effect of moisture stress was up to 88.95%. Moisture stress during the vegetative stage was also observed by Foroud *et al*, 1993 to reduce seed yield by 15% compared with their control. Moisture stress at later growth stages had a more marked effect on yield but there was little difference between them. Moisture stress reduced the number of nodes/plant and, when applied during the reproductive stage, reduced seed weight. Moisture stress also affected the nodal distribution of yield components (De Mooy, *et al* 1973).

Table 4: Mean yield of soybean varieties under nutrient and moisture stress

s/ no	Variety	Yield per plot (kg)			Stress susceptib. index		% yield reduction	
		Non-stress	P-stress	Moisture stress	P-stress	Moisture stress	P-stress	Moisture stress
1	TGx1954-1F	0.75	0.51	0.17	0.32	0.77	32.00	77.33
2	TGx1440-1E	0.71	0.48	0.22	0.32	0.69	32.40	69.01
3	TGx1910-14F	0.90	0.42	0.31	0.53	0.65	53.33	65.56
4	TGx1908-8F	0.71	0.68	0.38	0.04	0.46	4.22	46.48
5	TGx1904-6F	0.41	0.31	0.14	0.24	0.66	24.39	65.85
6	TGx1835-10E	0.18	0.16	0.15	0.11	0.17	11.11	16.67
7	TGx1951-4F	0.68	0.57	0.12	0.16	0.82	16.18	82.35
8	TGx1740-4F	0.31	0.28	0.16	0.10	0.48	9.68	48.38
9	TGx1485-1D	0.87	0.50	0.14	0.42	0.83	42.53	83.91
10	TGx1844-4E	0.88	0.66	0.15	0.25	0.88	25.00	88.95
11	TGx1937-1F	0.95	0.71	0.19	0.25	0.80	25.26	80.00
12	TGx1448-2E	0.77	0.60	0.24	0.22	0.68	22.21	68.83
13	TGx1935-3F	0.65	0.40	0.13	0.38	0.80	38.46	80.00
14	TGx1961-1F	0.82	0.33	0.15	0.59	0.81	59.76	81.71
15	TGx1965-7F	0.57	0.34	0.15	0.40	0.73	40.35	73.68
16	TGx1830-20E	0.88	0.46	0.27	0.47	0.69	47.73	69.32
17	TGx1956-1F	0.81	0.58	0.12	0.28	0.85	28.39	85.18
18	TGx1971-1F	1.10	0.68	0.15	0.38	0.86	38.18	86.36
19	TGx1019-2EN	0.39	0.33	0.14	0.15	0.64	15.38	64.10
	CV	25.1	15.3	16.8				
	SE	12.2	10.5	9.6				

Early maturing variety like TGx1835-10E had the least percent yield reduction; although it had a low yield under normal condition, this could be that moisture stress effect was not severe at its seed filling period either as result of escape mechanism from drought. Robert and Edward (2002) observed the seed filling period was more sensitive to moisture stress than seed growth rate and the effect of moisture stress on the duration of seed fill may be one way that stress reduces soybean yield.

CONCLUSION

Soybean yield is a function of the number of plants/plot, pods/plant, seeds/pod, and the size of the seed. Soybean is the most susceptible during the reproductive stages of growth. Once the plant starts to flower, it needs significant water right through to complete seed-fill. Suitable varieties for the northern guinea savannah must be early maturing that will probably escape drought stress at critical periods.

REFERENCES

Bouman, B.A.M. and T.P. Tuong, (2001). Field water management to save water and increase its productivity in irrigated lowland rice. Agric Water Manage. 49(1): 11-30.

Burriro,U.A.; Samoon, H.A.; Oad, F.C. and G.H. Jamro (2002). Crop coefficient (KC) and Water use efficiency of soybean as affected by soil moisture stress and fertility levels. Parkistan J. of Applied Sciences 2(12):1096-1098.

De Mooy, C.J. Pesek, J. and Spaldon, E. (1973). Mineral Nutrition. In: Caldwell B.E.(Ed). Soybean: Improvement, production and uses. Madison, USA. Pp267-352

Faroud, N; H.-H. Miindel, G. Saindon, and T. Entz (1993). Effect of level and Timing of Moisture stress on soybean plant development and yield components. Irrig. Sc. 13: 149-155

Mahmood,T; Saitou, K; and Kuroda, T (1999). Effect of moisture stress on the growth and yield of determinate and indeterminate types of soybean. Scientific Report of the Fac of Agric, Okayama. Vol. 88. pg 87-94.

Ishaq M.N. and Olaoye, G (2008) Expression of Heterosis in Sugarcane Genotypes under moisture stressed condition. African j. of General Agriculture Vol4 (2) pg 99-105

Robert, C.H; and K.T. Edward (2002). Effect of drought stress on soybean production. Extension Extra; Colleage of Agric &Biol Sc publ. Http://agriopubs.sdstate.edu/articles/ExEx8034.

Sodangi, I.A. Gwargwor, N.A.; and S.D. Josua (2006) Effect of inter-row spacing and weed interference on productivity of soybean in Maiduguri, Nigeria. Nig j. Weed science pp33-41