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BIOMASS AND SEED PRODUCTION OF TWELVE SOYBEAN VARIETIES IN FISH POND IN SOUTHEASTERN NIGERIA

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ABSTRACT

Replicated trials involving twelve soybean varieties grown in dry fish ponds were conducted in Umudike in the humid forest zone of south-eastern Nigeria to study biomass and seed production of the twelve soybean varieties in the dry season of 2002 and 2003. The trials were laid out as split plot in a randomised complete block design. The main plot treatments were the two years of 2002 and 2003 while the sub-plot treatments were twelve soybean varieties. The varieties were early TGX 1485-1D, TGX 1835-10E, TGX 1740-2E, TGX 1805-17F, TGX 1799-8F, TGX 1831-32F and medium TGX 1878-7E, TGX 1440-1E, TGX 1871-12E, TGX 1802-1F, NCRI Soy-8 and Cameroon Late. Soybean plants were more vegetative and greater in 2003 than 2002 by 50% for plant height, 142% for number of leaves per plant, 314% for shoot dry weight and 224% for root dry weight. Biomass production did not differ significantly among the varieties at 6 WAP. Seed yield ranged from 307.6kg/ha to 1265.7kg/ha in 2002 and from 212.2kg/ha to 2614.8kg/ha in 2003. On average, seed yield was significantly higher in TGX 1805-17F and TGX 1440-1E than other varieties except TGX 1878-7E, TGX 1835-10E and TGX 1799-8F.

Key words: Biomass, Seed yield, Soybean varieties, Fishpond, South-eastern Nigeria

INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is generally regarded a premium crop for its great importance in human nutrition and animal feed, and for its role in the cropping system as a good nitrogen fixer. The crop is rich in oil (21%) and protein (40%) contents (Johnson and Bernard, 1963) and in minerals (iron and calcium) and vitamin. With the protein content of 40% in the dry bean and 92% total digestible nutrient (Ahom, 1996), soybean is shown to compare even better than lean meat, egg or cow milk (Faryna, 1985).

In aquaculture operations, feed is an important input and accounts for about 50-60% of the recurring investment (Sahul Hameed *et al.*, 2002). The realization of the full potentials of aquaculture in developing countries such as Nigeria has, however, been militated by expensive fish feed. Soybean with its cheap and high-level protein has been reported to have great potentials to substitute for expensive animal or fish meal (Singh *et al.*, 1987). Integration of soybean production into the mixed farming system of south-eastern Nigeria would require the exploitation of fertile pond soils during the dry season (November to March). Farmers in the region use the rainy period (April to November) for arable crop production and rearing fish while the relatively dry months of December to March are periods of low farm activities. With irrigation, the dry periods could be suitable for extra crop production and could be utilized to grow soybean in dry fish ponds to provide feed.

Successful cultivation of soybean during the dry season would depend on knowledge of adaptable and high yielding varieties, as there are wide ranges of photoperiod responses in soybean (Howell, 1963). There is a dearth of published information on biomass and seed production of soybean genotypes grown in dry fishponds in Nigeria. The objective of this study was therefore, to evaluate twelve varieties of soybean for biomass and seed production in dry fishpond in southeastern Nigeria.

MATERIALS AND METHODS

The study was conducted between January and April 2002 and 2003, in the fish farm of Michael Okpara University of Agriculture, Umudike, South-eastern Nigeria. Umudike is situated at Latitude 5° 29'N and Longitude 7° 32'E and an elevation of 122m above sea level. The soil of the site is a sandy loam classified as an ultisol (Agboola, 1979). Some meteorological information of Umudike notably, the monthly (January - December) rainfall, temperature and relative humidity obtained from the National Root Crops Research Institute (NRCRI) Meteorological station at Umudike were recorded for 2002 and 2003.

The experiment was a split plot laid out in a randomised complete block design with three replications. The main plot treatments were the two years of the experiment (2002 and 2003) while the sub-plot treatments were twelve soybean varieties. The soybean varieties comprised six each of early and medium maturity types obtained from the National Cereals Research Institute (NCRI), Badeggi, Nigeria. The early maturing varieties were TGX 1835-10E, TGX 1485-1D, TGX 1740-2E, TGX 1805 17F, TGX 1799-8F and TGX 1831-32F while the medium maturity varieties were TGX 1878-7E, TGX 1440-1E, TGX

1871-12E, TGX 1802-1F, NCRI Soy-8 and Cameroon late. The varieties were sown in three fish ponds constructed in November 2002 prior to stocking of fingerlings in April. Ridges (30 cm high) were made 50 cm apart in the fishponds measuring 12 m x 5 m. Two rows of each variety were planted at two seeds per hole along the crest of the ridges on 10 January 2002 and 17 January 2003. Each plot was two rows wide and the seedlings were thinned to one plant per hole 2 weeks after planting (WAP). A spacing of 50 cm x 5 cm was maintained to give a plant population density of 400,000 plants/ha equivalent. Composite soil samples were collected from representative locations of the pond on 20 January 2002 and 10 January 2003. The ponds were fenced to a height of 50 cm with polythene sheets and bamboos to protect the plants from rodent damage 5 WAP.

Compound fertilizer N:P:K: Mg (12:12:17:2) was applied at the rate of 50 kg N/ha (416 kg N:P:K: Mg/ha) at 3 WAP in 2002 and at 25 kg N/ha (208 kg N:P:K: Mg 12:12:17:2/ha) at 2 WAP in 2003. The nitrogen rates were as recommended by Okpara *et al.*, 2002 for soybean in south-eastern Nigeria. The nitrogen rate applied in 2002 was higher due to removal of topsoil during pond construction. Lime was applied at 1 t/ha during seedbed preparation in 2002. The ponds were drained at the periods of rain and irrigated at dry periods. Hoe weeding was done at 4 WAP. No pest control measures were applied despite serious attack by Nezara in 2003, to prevent pollution of the fishponds. After harvest of soybean in April 2002 the pond was stocked with fingerlings (*Heterobranchus sp*) and the fish harvested in December 2002. The production system was a semi-intensive fish-grow-out (raising the catfish fingerlings from fingerlings to table size) involving polyculture of *Heterobranchus longifilis* and tilapia. Routine pond management practices during fish rearing involved application of soybean meal and poultry manure and feeding the fish using supplemental feed (14% mean protein content) compounded from soybean, rice bran and brewery waste for 9 months period (April December).

Soil pH was measured in 1:2.5 soil: water ratio. Total nitrogen in the pond soil was analysed by the kjeldahl method (Pearson, 1976). Phosphorus was determined using the Bray 1 method. Organic matter (OM) content of the pond soil was estimated by the wet oxidation method of Walkley and Black (1934). Data on soybean were taken on plant height (cm), number of leaves per plant, shoot dry weight (g/plant) and root dry weight (g/plant) at 6 WAP. Records were also taken on days to 50% flowering, number of pods/plant, number of seeds/pod, 100-seed weight (g) and seed yield (kg/ha). Analysis of variance of data was done according to Gomez and Gomez (1984).

RESULTS

Rainfall was generally low in the months of November to March (dry season) and high during the period from April to October (wet season) (Table 1). While rainfall was early in coming and stabilizing in April in 2002, it was late, and stabilizing about May in 2003. Relative humidity was lower but temperature higher in the months of November through March, coinciding with the periods of low and infrequent rainfall.

The pond soil used for the 2003

experiment was significantly higher in nitrogen by 195% and phosphorus by 217% (Table 2). Organic matter content of the pond soil was also higher in 2003 than 2002, although no statistical differences occurred between the years. On the other hand, pH was lower in 2003 than 2002.

Table 1: Weather records for the site of the experiments in 2002 and 2003

	Month											
	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct..	Nov.	Dec.
2002												
Total Rainfall (mm)	3.1	107.1	68.5	259.0	436.3	240.1	359.8	333.7	238.5	247.5	57.8	0.0
Max. Tempt. (^{0}C)	32.0	34.0	33.0	32.0	32.0	30.0	30.0	28.0	29.0	30.0	32.0	33.0
Min. Tempt. (^{0}C)	21.0	22.0	24.0	24.0	24.0	23.0	23.0	23.0	22.0	22.0	23.0	21.0
Rel. humidity (%)	36.0	53.5	74.5	80.0	78.5	81.0	88.0	83.0	81.0	82.0	71.0	50.0
2003												
Total Rainfall (mm)	0.0	37.9	119.5	159.8	231.4	282.4	491.1	339.8	340.8	180.2	69.2	0.0
Max. Tempt. (^{0}C)	33.0	33.0	34.0	34.0	32.0	30.0	30.0	29.0	30.0	31.0	32.0	32.0
Min. Tempt. (^{0}C)	22.0	24.0	24.0	24.0	23.0	23.0	23.0	23.0	22.0	23.0	23.0	20.0
Rel. humidity (%)	56.0	59.5	67.5	75.0	77.5	81.5	79.5	82.5	81.0	75.5	73.5	65.1

sphorus and organic matter contents and pH of the pond soil in 2002 and 2003

	2002	2003	LSD ($_{0.05}$)
Nitrogen (%)	0.044	0.130	0.042
P (mg/kg)	8.1	25.7	8.1
Organic matter (%)	1.61	2.19	NS
Soil pH (water)	5.4	4.5	NS

At 6 WAP in both years and across the twelve varieties, plant height and number of leaves per plant varied significantly while shoot and root dry weights did not differ (Table 3). Plant height ranged from 26.2 cm in TGX 1799-8F to 41.3 cm in TGX 1878-7E with a mean of 30.2 cm in 2002 and from 40.0 cm in TGX 1871-12E to 60.1 cm in TGX 1485-1D with a mean of 46.0cm in 2003. In 2002, TGX 1878 7E produced significantly taller plants than other varieties except TGX 1802-1F, TGX 1835-10E, TGX 1740-2F and TGX 1805-17F. In 2003, however, TGX 1485-1D produced significantly taller plants than other varieties except NCRI soy-8, TGX 1835-10E, TGX 1740 2F and TGX 1805-17F.

The number of leaves per plant

Table 3: Growth of twelve varieties of soybean in fishpond at 6WAPin 2002 and 2003

Variety	Plant height (cm)			Number of leaves/plant			Shoot dry matter in (g/plant)			Root dry matter (g/plant)		
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
TGX1878-7E	41.3	45.8	43.6	6.7	15.0	10.9	1.4	3.2	2.3	0.20	0.52	0.36
TGX1440-1E	30.2	46.3	38.3	8.7	19.0	13.9	1.0	3.6	2.3	0.20	0.49	0.35
TGX1802-1F	35.3	46.6	41.0	6.7	14.3	10.5	1.0	3.8	2.4	0.29	0.48	0.39
TGX1871-12E	29.4	40.0	34.7	6.3	13.8	10.1	0.8	2.3	1.6	0.16	0.50	0.33
NCRISoy-8	31.2	56.5	43.9	6.3	21.5	13.9	0.9	5.1	3.0	0.13	0.63	0.38
Cameroon Late	32.1	48.5	40.3	6.3	15.8	11.1	0.8	4.5	2.7	0.17	0.46	0.32
TGX1835-10E	35.1	54.7	44.9	7.3	12.7	10.0	1.4	4.0	2.7	0.25	0.50	0.38
TGX1485-1D	29.2	60.1	44.7	6.5	20.2	13.4	0.9	6.1	3.5	0.12	0.91	0.52
TGX1740-2F	38.0	53.1	45.6	6.3	17.0	11.7	1.3	4.4	2.9	0.14	0.53	0.34
TGX1805-17F	33.9	52.2	43.1	5.2	12.0	8.6	0.7	4.4	2.6	0.12	0.55	0.34
TGX1799-8F	26.2	47.8	37.0	5.8	14.2	10.0	0.7	4.2	2.5	0.12	0.52	0.32
TGX1831-32F	39.7	49.9	44.8	5.7	13.3	9.5	1.1	4.1	2.6	10.18	0.51	0.35
Mean	33.5	50.1		6.5	15.7		1.0	4.1		0.17	0.55	

	Plant height	Number of leaves/plant	Shoot dry matter	Root dry matter
LSD ($_{0.05}$) for two years (Y) means =	2.7	1.0	0.6	0.07
LSD ($_{0.05}$) for two years (V) means =	6.5	2.5	NS	NS
LSD ($_{0.05}$) for Y x V means =	9.2	3.5	NS	0.23

ranged from 5.2 in TGX 1805-17F to 8.7 in TGX 1440-1E with a mean of 6.0 in 2002 and from 12.0 in TGX 1805-17F to 21.5 in NCRI soy-8 with a mean of 14.6 in 2003. In 2002, TGX 1440-1E produced significantly more leaves per plant than other varieties except TGX 1835-10E. However, in 2003, NCRI Soy-8 had significantly more leaves per plant than other varieties except TGX 1485-1D, TGX 1440-1E and

TGX 1740-2F. Shoot and root dry matter did not differ among the varieties in both years. In general, soybean plants in 2003 were greater than the 2002 crop by 52% for plant height, 143% for number of leaves per plant, 319% for shoot dry weight and 217% for root dry weight. Data on yield and yield components of the varieties are presented in Table 4. Days to 50% flowering were significantly earlier in TGX 1835 10E and TGX 1799-8F than other varieties except TGX 1805-17F and TGX 1485-1D. All soybean plants flowered earlier in 2003 than 2002. TGX 1871-12E in 2002 gave significantly more pods per plant than other varieties. In 2003, however, TGX 1440-1E and TGX 1805-17F had more pods per plant than other varieties.

The number of seeds harvested per pod was, on average, significantly higher in TGX 1878-7E than other varieties except Cameroon Late and TGX 1485-1D The weight of 100-seeds did not differ significantly among the varieties in both years.

Seed yield ranged from 307.6 kg/ha in TGX 1831-32F to 1265.7kg/ha in TGX 1871-12E with a mean of 676.0kg/ha in 2002 and from 212.2 kg/ha in NCRI Soy -8 to 2614.8 kg/ha in TGX 1805-17F with a mean of 937.3kg/ha in 2003. On average, seed yield was significantly increased in TGX 1805-17F than other varieties except TGX 1440-1E, TGX 1878-7E, TGX 1835-10E and TGX 1799-8F. While some varieties showed yield increases, others recorded yield reductions in 2003, in which there was severe insect pest attack by *Nezara* sp. The greatest yield increases occurred in TGX 1805-17F (503%), TGX 1799-8F (229%) and TGX 1835-10E (171%) while yield depressions occurred in TGX 1485-1D, TGX 1871-12E, TGX 1740-2F, NCRI Soy-8 and Cameroon Late. However,

Seed yield showed highly significant positive correlation with number of pods per plant and number of seeds per pod (Table 5). Days to 50% flowering showed a significant negative correlation with number of seeds per pod and 100-seed weight.

DISCUSSION

The contribution of soybean to soil organic matter content will depend on the dry matter production of soybean and largely on the amount of crop residues recycled (Singh *et al.*, 2002). Although, the soybean varieties did not differ in dry matter accumulation at 6 WAP, better vegetative growth were produced in 2003 attributable to the higher pond soil fertility following the stocking of the pond with fingerlings and the routine pond management practices involving application of feed (Soybean biomass/grain) and poultry manure as was the case in this study in 2002.

In this study, all soybean varieties attained 50% flowering earlier in 2003 compared to 2002, indicating that the fertility level of the pond may also have resulted in early flowering being hastened by adequate nutrient supply. Among the varieties, the earliest to flower were TGX 1835-10E, TGX

1805-17F and TGX 1799-8F on average. The major source of yield variation among the varieties was number of pods per plant and number of seeds per pod as these attributes positively and significantly correlated with seed yield. Thomas *et al.* (1981) also found that a major source of yield variations in their experiments with sorghum was grain number while other workers (Ariyo, 1991; Ariyo *et al.*, 1987; Kaul *et al.*, 1978) identified number of pods per plant as an important component of yield.

The highest average seed yields of 1524.3kg/ha and 1369.9 kg/ha obtained for TGX 1805-17f and TGX 1440-1E respectively, were higher than the 573.4 kg/ha for TGX 1805-17f and 760.0 kg/ha for TGX 1440.1E obtained by Okpara and Ibiam (2000) in a similar environment during the period from August to November. Conversely, the average yield of 756.1 kg/ha obtained for TGX 1485-1D in the present study, was lower than the over 1000 kg/ha average seed yield obtained for the same variety by other workers (Okpara and Ibiam, 2000; Okpara *et al.*, 2002) in a similar environment in August to November. This suggests that the response of soybean genotypes to increasing photoperiods as was the case in this experiment, conducted between January and April, differs from that to decreasing photoperiods as exists in the months of August to November in south-eastern Nigeria. Howell (1963) had reported a wide range of photoperiodic responses in soybean and noted that environmental variation is a very important factor affecting crop performance.

There was severe insect pest attack by *Nezara* sp. in 2003, evidently from non-application of pest control measures in the fish pond. Damage by the bug was mainly on the pods, which became scaly and flattened. Consequently, yield depressions of 76% for TGX 1871-12E, 73% for NCRI Soy-8, 44% for TGX 1749 2F, 8% for TGX 1485-1D and 3% for Cameroon Late occurred. Jackai *et al.* (1986) also reported that *Nezara viridula* can cause losses from between 25% and 60% of soybean in some locations in Nigeria. However, yield increases occurred in some varieties despite the serious attack by *Nezara sp* in the second year. The highest yield increases of 503%, 229% and 171% occurred in TGX 1805-17F, TGX 1799-8F and TGX 1835-10E respectively, indicating the apparent resistance of these varieties to the insect pest. Dashiell *et al.* (1987) had reported the existence of soybean lines that have a moderate level of field resistance to stink bugs (*Nezara*). Overall, seed yield was higher in 2003 than 2002 by 39%, due mainly to the greater fertility of the pond soil in the former. While the earlier rains in 2002 contributed partly to nutrient loss from leaching that year, manure application during fish rearing after the harvest of soybean in 2002 enhanced fertility of the pond soil in 2003. Asiegbu (1985) attributed the poor performance of late planted crops, in part, to loss in soil fertility from leaching caused by earlier rains. In the present investigation, the pond soil was higher in 2003 than 2002 by 195% for nitrogen and 217% for phosphorus.

Generally, the findings demonstrated that soybean could be successfully integrated into the mixed farming system-involving crop and fish farming in southeastern Nigeria. Such integration would benefit fish farmers not only because conventional feeds are very expensive but also because soybean as an annual of relatively short duration with high nitrogen fixation and high protein content (Giller and

Wilson, 1993); can provide cheap high quality feed and improve the nitrogen economy of fish ponds. In the order of performance, the varieties with high seed yield potentials in Umudike agroecosystem of south-eastern Nigeria were TGX 1805-17F, TGX 1440-1E, TGX 1878-7E, TGX 1835-10E and TGX 1799-8F.

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Table 4: Seed yield and yield components of twelve varieties of soybean in fishpond in 2002 and 2003

Variety	Days of 50% flowering			Number of pods/plant			Number of seeds/pod)			100-seedweight			Seed yield (kg/ha)		
	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean	2002	2003	Mean
TGX1878-7E	46	38	42	8.9	12.4	10.7	2.5	2.1	2.3	8.9	7.8	8.4	815.7	963.2	889.5
TGX1440-1E	46	41	43.5	15.9	24.5	20.2	1.9	2.0	2.0	9.5	7.7	8.6	1167.9	1571.8	1369.9
TGX1802-1F	46	38	42	8.3	8.4	8.4	1.3	2.0	1.7	10.1	10.0	10.1	447.0	702.0	574.5
TGX1871-12E	48	41	44.5	22.5	4.5	13.5	1.7	2.0	1.9	8.5	8.5	8.5	1265.7	308.2	787.0
NCRISoy-8	41	41	41	9.9	3.6	6.8	1.7	1.9	1.8	11.5	7.7	9.6	799.3	212.2	505.8
Cameroon Late	44	38	41	7.5	9.6	8.6	2.1	2.0	2.1	10.3	8.4	9.4	660.8	640.1	650.4
TGX1835-10E	40	33	36.5	6.9	13.9	10.4	1.7	2.2	2.0	10.1	10.7	10.4	478.8	1296.8	887.8
TGX1485-1D	40	36	38	7.2	8.8	8.0	2.0	2.1	2.1	12.7	9.4	11.1	788.3	723.9	756.1
TGX1740-2F	43	37	40	7.2	4.8	6.0	1.8	2.0	1.9	10.4	7.2	8.8	545.9	303.0	424.5
TGX1805-17F	42	33	37.5	7.3	24.4	15.9	1.4	2.3	1.9	10.8	10.9	10.9	433.8	2614.8	1524.3
TGX1799-8F	41	32	36.5	6.1	14.2	10.2	1.7	2.2	2.0	9.7	10.8	10.3	401.3	1319.3	860.3
TGX1831-32F	44.7	36.3	40.5	5.1	7.2	6.2	1.6	2.0	1.8	10.2	10.3	10.3	307.3	591.7	449.7
Mean	43.5	37.0		9.4	11.4		1.8	2.1		10.2	9.1		676.0	937.3	

	Days to 50% flowering	Number of pods/plant	Number of seeds /pod	100-seeds weight	Seeds yields
LSD $(_{0.05})$ for two years (Y) means	0.8	NS	0.1	NS	280.7
LSD $(_{0.05})$ for two years (V) means	2.0	6.5	0.3	NS	687.6
LSD $(_{0.05})$ for Y x V means	2.8	9.2	0.4	NS	972.5

Table 5: Correlation coefficients between agronomic characters and seed yields across twelve soybean genotypes

	Plant height	Number of leaves Per plant	Days to 50% flowering	Shoot dry weight.	Root dry Weight Per Plant	No of Pods	Number of seeds per pod	100 seed weight	Seed yield
Plant height	-	.424**	-.197	.739**	.510**	-.129	.159	-.143	-.049
Number of leaves/plant		-	.333*	.313	.267	-.131	-.189	-.175	-.203
Days to 50% flowering			-	-.204	.039	-.176	-.597**	-.342*	-.315
Shoot dry weight				-	.504**	-.123	.164	.009	-.086
Root dry weight					-	-.114	.268	-.190	-.097
Number of pods/plant						-	.368*	.140	.956**
Number of seeds/pod							-	.193	.496**
100-seed weight								-	.163
Seed yield									-

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