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Effect of Density of Planting on Yield of Two Soybean Cultivars

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ABSTRACT. The yield and yield components of two varieties of soybean [*Glycine max* (L.) Merrill], Bossier and Improved Pelican were compared in two experiments in 1987 and in 1988 at a range of planting densities from 10 to 40 plants/m. The experimental design was a split plot randomized block with three replicates; plant density formed the main plot treatments and the cultivars formed the sub plot. The optimum density of planting for Bossier, a determinate type was 20 plants/m while that of Improved Pelican, an indeterminate type, was 10 plants/m. Improved Pelican which was more susceptible to lodging showed greater yield reductions at higher densities than Bossier which was lodging resistant. Although number of branches per plant generally increased with increasing density, there was no significant density effect on the number of nodes per plant. Number of pods/plant, seeds/pod and seed weight decreased at high densities in 1987 as well as in 1988, indicating a consistent response across years.

Soybean is cultivated in Nigeria mainly in the middle savanna zone. However, increased demand for concentrates in livestock feed and vegetable oil for human needs has generated interest in the expansion of soybean production in the southern parts of the country. In these areas, wide row spacings of between 90 to 100 cm are used and seeds are often spaced 15 to 30 cm apart giving about 37,000 to 74,000 plants/ha. Adapted exotic varieties such as Bossier and Improved Pelican have no recommended spacing.

Plant population studies in the temperate region are well documented. Hartwig (1957), Cooper (1971) and Wilcox (1974) have shown that planting soybean above an optimum rate resulted in increased lodging and possibly decreased yield. Shaw and Weber (1966) also discussed the effect of lodging on yield of soybeans.

The purpose of this study is to determine the effect of different population densities on yield and components of yield of two soybean cultivars.

Materials and Methods

Two field experiments were carried out at the University of Benin Research Farm, Benin City in the rainforest zone of Nigeria in 1987 and in an identical manner in 1988 but in different plots and with a new randomized pattern. The soil type was the Benin fasc of sedimentary origin classified as ferralitic soil (D'Hoore 1984). The two soybean cultivars used were Bossier, a short bushy type with determinate growth habit and Improved Pelican, a tall vegetative indeterminate type.

The first experiment was sown on April 12, 1987 on the flat with inter-row spacing of 60 cm in plots 3m x 6m. Seeds were drilled and thinned to appropriate population after two weeks. There were three planting densities of 10, 20 and 40 plants/m linear row, corresponding to approximately 166,000, 333,000 and 666,000 plants/ha, respectively. The site carried a crop of cowpeas in the previous season. The second experiment was sown on April 16, 1988. Details of the chemical composition of the soil are shown in Table 1. Table 2 shows the precipitation and temperature regime during the period of experimentation.

Table 1. Chemical composition of soil before cropping

	1987	1988
pH (water)	4.6	4.45
Organic carbon (%)	1.3	1.17
Organic matter (%)	1.96	1.43
Total N (%)	0.17	0.09
Available P (ppm)	1.5	2.72
Exchangeable K (meq/100g)	1.1	0.08

Table 2. Meteorological Conditions at Benin City, Nigeria (March - October)

	Mar	Apr	May	June	July	Aug	Sept	Oct
1987								
Total rainfall (mm)	66.4	51.3	143.8	205.7	270.5	349.2	345.9	188.1
Max. temperature (°C)	33.8	34.2	33.6	31.9	30.7	29.6	30.2	32.1
Min. temperature (°C)	23.3	24.1	23.1	27.4	22.7	23.3	22.6	23.8
1988								
Total rainfall (mm)	109.3	220.7	189.4	222.1	279.2	174.4	471.6	178.3
Max. temperature (°C)	33.7	33.7	33.3	31.2	29.1	28.3	29.4	31.4
Min. temperature (°C)	24.7	23	22.5	22	21.9	22.1	22.2	22.1

The experimental design was a split plot randomized block with three replicates; planting density formed the main plot treatment and the cultivars formed the sub-plot. Insects were controlled by a 3-weekly spraying of monocrotophs (Nuvacron) at 3ml/l of water, starting at the onset of flowering.

Record was taken of number of days to 50% flowering, number of pods per plant, number of internodes per plant, average internode length and number of branches per plant from 10 randomly selected plants in each plot. Number of days to 50% flowering was the number of days from sowing until half of the number of plants have flowered. Plant height was the stretched out length of the plant from the ground to its extremity, whether that be its main stem or a branch. Lodging was assessed visually by using a scale of 1 to 5 based on the average erectness of the main stem at maturity. All plants erect scored 1 while all plants prostrate scored 5; scores of 2, 3, and 4 were assigned, depending on severity of lodging. Grain yield and components of yield were obtained from the three centre rows of the plots in both experiments. Seed weights were adjusted to 13% moisture.

Statistical analysis of data followed a simple analysis of variance.

Results

Bossier, a determinate cultivar, had its maximum seed yield at 20 plants/m, while maximum seed yield for Improved Pelican, an indeterminate cultivar, was obtained at 10 plants/m (Table 3). Generally, seed weight, number of seeds per pod and number of branches per plant decreased with increase in population density. There was an increase in plant height as well as stalk lodging as plant population increased, with Improved Pelican, the taller growing cultivar, being more susceptible to lodging. Soybean plants also tended to have longer internodes as plant density was increased. However, lodging was relatively low in both years, even in Improved Pelican, being an average of 2.1 in 1987 (Table 3) and 1.9 in 1988 (Table 4).

Number of days to flowering which was not significantly affected by population density in 1987 increased significantly as plant population increased in 1988 (Table 4). Nevertheless, there appeared to be a consistent response by the soybean cultivars at varying population densities across years.

Discussion

The plants of most soybean cultivars have a tremendous capability of adjusting their growth according to conditions of plant population and competition. At low populations, the plants produce more and larger branches than at high population stands (Delorit *et al.* 1984). In the current study, soybean plants produced more branches at lower plant populations than at higher populations. Apparently, the plants were mutually shaded at high populations and tended to elongate to a higher degree and produced fewer lateral branches. The taller plants obtained at the higher populations give credence to this reasoning.

Table 3. Grain Yield and Components of Yield of Two Soybean Cultivars, 1987

Cultivar	Plant Density (plants/m)	Grain Yield (Kg/ha)	Days to 50% Flowering	Weight of 100 Seeds (g)	Number of Seeds Per Pod	No. of Pods Per Plant	Plant Height (cm)	No. of Internodes Per Plant	Internde Length (cm)	No. of Branches Per Plant	Lodging Score
Bossier	10	2,310	45	15.9	2.67	82.3	32.7	8	4	6.7	1
	20	2,593	43	15.3	2	74.3	42.7	8.7	4.3	4.3	1.3
	40	2,239	46	14.6	1.67	68.6	47.3	9	3.3	3.3	1.7
	Mean	2,381	44.7	15.3	2.1	75.1	40.9	8.6	3.9	4.8	1.3
Improved Pelican	10	2,426	42	14.7	2.67	84.3	71	13.3	4.3	3.3	1.7
	20	2,141	46	14.2	2.33	71.7	81.3	14.3	6	2.3	2
	40	1,856	48	14.4	1.67	62.3	88.3	15	5.7	1.7	2.7
	Mean	2,142	45.3	14.4	2.2	72.8	80.2	14.2	5.3	2.4	2.1
LSD (o.o5) to compare plant density means within each cultivar		80.9	NS	0.47	0.7	4.01	5.57	NS	NS	0.62	0.4
LSD (0.05) to compare cultivar means		114	NS	NS	NS	NS	5.78	2.2	NS	NS	0.2

Table 4. Grain Yield and Components of Yield of Two Soybean Cultivars, 1988

Cultivar	Plant Density (plants/m)	Grain Yield (Kg/ha)	Days to 50% Flowering	Weight of 100 Seeds (g)	Number of Seeds Per Pod	No. of Pods Per Plant	Plant Height (cm)	No. of Internodes Per Plant	Internde Length (cm)	No. of Branches Per Plant	Lodging Score
Bossier	10	2,114	44	14.1	2.3	85.3	36	8	3.7	7.3	1
	20	2,427	43	13.9	2.6	87	45.6	7	4.6	7	1.3
	40	2,001	46	14.2	2.3	72	55	6.3	5.2	6	2.1
	Mean	2,181	44.3	14.1	2.4	81.4	45.6	7.1	4.5	6.9	1.5
Improved Pelican	10	2,320	43	12.6	3	85.3	51.6	13	4.3	3.3	1.2
	20	2,213	48	11.9	2.6	79	59.6	13	5.4	2.3	1.7
	40	1,942	49	12.4	2.3	76	70.6	12.6	5.6	1.6	2.7
	Mean	2,158	46	12.3	2.7	80.1	60.7	12.9	5.1	2.4	1.9
LSD (o.o5) to compare plant density means within each cultivar		NS	1.52	NS	NS	2.76	4.36	NS	1.2	0.89	0.14
LSD (0.05) to compare cultivar means		NS	NS	0.8	NS	NS	6.16	2.05	NS	1.26	0.17

Several workers (Cooper 1971, Hartwig 1957, Johnson and Harris 1967, and Wilcox, 1974) have attributed reduction in grain yield of soybean planted at high density to lodging. In our study, branch breakage was noticeable in Bossier and may have accounted for seed yield losses at harvest. Additionally, higher population density resulted in taller

plants which aggravated lodging, especially in Improved Pelican. However, although lodging scores were relatively low, their magnitude was sufficient to account for the yield reductions obtained at the higher plant densities.

There is considerable evidence that seed yield is principally a function of seed number produced. Evans (1975) reported that the most important components of yield variation are number of fruiting nodes and seed set per pod. In the present investigation, Bossier attained its optimum seed yield at the medium planting density during which the number of pods per plant and the number of seeds per pod were highest. Similar results were obtained for Improved Pelican but at the lowest plant population, after which further increase in population depressed yield. Thus, this cultivar expressed vigorous growth at lower plant population than at higher population. Fontes and Ohlrogge (1972) have shown that as plant density increased, weaker plants became barren and, although these plants utilized water and nutrient, they contributed nothing to yield. Similar factors may be operative in this trial.

The results of the current investigation have shown that the optimum planting density for Bossier is 20 plants/m corresponding to approximately 333,000 plants/ha. This agrees with the report of Hoggard *et al.* (1978) who obtained the highest seed yield for a determinate soybean cultivar at 23 plants/m. With regards to Improved Pelican, yield would be maximized at a population of 10plants/m corresponding to 166,000 plants/ha.

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تأثير كثافة النباتات على محصول صنفين من فول الصويا

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أقيمت تجربتان حقليتان في موسمي ١٩٨٧، ١٩٨٨ في مزرعة الأبحاث بجامعة بنين بنيجيريا من أجل دراسة تأثير كثافة النباتات على المحصول ومكوناته لصنفين من فول الصويا - أحدهما بوسير وهو قصير محدود النمو والآخر بليكان المحسن وهو صنف طويل غير محدود النمو. تم اختيار القطع المنشقة كتصميم تجريبي وكان عدد المكررات ثلاثة حيث خصّصت القطع الرئيسية لثلاث كثافات هي ١٠، ٢٠، ٤٠ نبات للمتر المربع التي تعادل ١٦٦٠٠٠، ٣٣٣٠٠٠، ٦٦٦٠٠٠ نبات للهكتار والقطع المنشقة للصنفين. ولقد دلت النتائج على أن الكثافة المثلى اختلفت باختلاف الصنفين بالنسبة للصنف بوسير كانت الكثافة المثلى هي ١٠ نباتات للمتر المربع وللصنف بليكان المحسن كانت ٢٠ نبات للمتر المربع. وكان الصنف الأخير معرضا للرقاد أكثر من الأول خاصة تحت الكثافات العالية والذي كان سبباً في انخفاض محصول هذا الصنف. وبالرغم من أن عدد الأفرع للنبات الواحد قد ازدادت بزيادة الكثافة إلا أن عدد العقد للنبات لم تتأثر بتغيير الكثافة. وبزيادة الكثافة انخفض عدد القرون في النبات، عدد البذور في القرن ووزن البذور.