The effects of different spacings and phosphorus application on the growth and yield of cowpea *(Vigna unguiculata*(L).) (Walp)

S. U. REMISON, B. BELLO AND T. OKUNARIWO
National Cereals Research Institute,
P. M. B. 5042, Ibadan, Nigeria.

Abstract

Cowpea cv. Prima was grown at six densities and three P levels in experiments made over three seasons in 1974 and 1975. In all experiments, number and weight of pods per plant decreased with increase in density whilst number and weight of pods per m^2 and grain yield increased linearly with density. Weight of haulms and total dry matter yield also increased with density. P generally promoted vegetative growth and in the early season of 1975 it delayed flowering significantly. There was significant P x density interaction in the early season of 1975 for weight per pod, harvest index and weight of pods per plant and per m^2;

Introduction

Cowpea is often sown at such wide spacings that the full potential of the crop's photosynthetic activity is not exploited due to incomplete ground coverage. Ojehomon and Bamiduro (1971) indicated that cowpea could be grown at spacings closer than 90 x 30 cm in the rainforest zone of Nigeria. Ezedinma (1974) later showed that close spacing between and within rows increased the biological and agronomic yields of cowpea. Akinola and Davies (1978) grew several cowpea varieties at 90 x 50 cm and found that the erect varieties gave low yield. They attributed the low yield of the erect varieties to sparseness of foliage combined with low 'forage yield index', due to limited ground cover. Thus the yield of erect cowpea varieties could be increased by sowing at dense populations.

Studies on P requirement of cowpea are few. Tewari (1965) noted that P application produced high number of nodules but Nangju (1973) found to response to N and P fertilizers. There are also few reports on the influence of planting density on cowpea under different levels of fertilizer application. For example, Stewart (1969) grew cowpea cv. Princess Anne at various spacings and NPK levels and noted that yields were higher at closer spacings but found no response to NPK fertilization. There is no report on spacing/fertilizer studies of cowpea in Nigeria. The present work describes field experiments carried out over three seasons on the influence of planting density and phosphate application on cowpea (*Vigna unguiculata* (L.) Walp).

Materials and Methods

Field experiments were carried out in 1974 and 1975 at Ibadan in the rainforest zone of Nigeria to determine the effects of planting density and phosphate application on cowpea cv. Prima. Prima is an erect, low branching, determinate and early maturing cultivar. The first experiment was sown on 19 April 1974; the trial site had a pH of 5.9, 21 ppm available P and 0.08% total N. The second and third experiments were sown on 29 April and 19 September 1975; the trial sites had a pH of 5.8, 12 ppm available P, 0.09% total N and a pH of 5.6, 16 ppm available P and 0.05% total N respectively. In all experiments plot size was 3.6 x 3.6m. Three P levels (0.45 and 90kg (P_2O_5 ha−1) and six planting densities were compared in a 3 x 6 factorial scheme with three replicates. The spacings and densities of plants after thinning were:—

spacing (cm)	plants/m2	plants/ha
90 x 30	3.7	37,000
56 x 28	6.0	60,000
46 x 23	9.9	99,000
40 x 20	12.5	125,000
36 x 18	15.4	154,000
30 x 15	22.2	222,000

P was applied as single superphosphate. Basal applications of 26 kg N ha^{-1} as ammonium sulphate and 60 kg K_2O ha^{-1} as muriate of potash were given to all plots at planting. Insects were controlled by spraying with Gammalin 20 at 21, 35 and 49 days after planting.

Observations were made on days to 50% flowering, number of pods, weight of pods, weight per pod, weight of seeds per pod, weight of 100 test seeds, shelling percentage (seed weight/pod weight) and grain yield. The weight of haulms, total dry matter yield and harvest index (dry weight of seed/total plant dry weight) were also recorded

Results

In the first experiment in 1974, P application had no significant effect on all the growth characteristics recorded and so no data are presented for any P effects

Density had significant effect (P / 0.05) on flowering (Table 1) but this did not follow any consistent pattern. The size of individual pods was not significantly affected by density (Table 1) but the weight of seeds per pod was generally greater at the higher densities (P / 0.01). Planting density had significant effect on weight of 100 seeds (P / 0.05), shelling percentage and harvest index (P / 0.001) but there was no consistent pattern in these results (Table 1). However, the lowest plant population had the lowest shelling percentage and harvest index. Weight of haulms and total dry matter yield increased up to the maximum with density (Table 1). Number of pods per plant decreased with increase in planting density (P /0.001) and pods per m2 increased with increase in density (P / 0.001) (Fig. 1). Weight of pods per plant and per m2 were similarly affected by density. Grain yield increased significantly (P / 0.001) with increase in planting density (Fig. 1).

In the early season of 1975, P had significant effect (P/0.001) on days to 50% flowering. Plots with 0, 45 and 90 kg P_2O_5 ha^{-1} flowered at 39.4, 40.1 and 40.3 days respectively. P also had significant effect (P / 0.001) on weight of haulms; 0, 45 and 90 kg P_2O_5 ha^{-1} produced haulms of 1495, 1640 and 1875 kg ha^{-1} respectively.

Planting density had significant effect (P / 0.05) on flowering but again there was no consistent pattern (Table 2). Weight of 100 test seeds and shelling percentage were not affected by density. Weight of haulms and total dry matter yield increased (P / 0.001) up to the maximum with density (Table 2). Number of pods per plant decreased, pods per m2 increased and grain yield increased (P / 0.001) with increase in planting density (Fig. 2).

There was significant P x density interaction for weight per pod (P / 0.01), weight of seeds per pod and harvest index (P / 0.05) though the main effects were not significant (Table 3). P x density interaction was also significant for weight of pods per plant and per m2. Pods were generally heavier, weight of seeds per pod and harvest index greater at lower densities especially at the highest level of P applied. On the other hand, at the highest density weight per pod and weight of seeds per pod were lowest at the intermediate P (45 kg P_2O_5 ha^{-1}) treatment. Weight of pods per plant decreased with increase in density (P / 0.001); at the lowest density, the plots without applied P had the lowest pod weight whilst the plots with 90 kg P_2O_5 ha^{-1} had the highest pod weight (Fig. 2). At the highest density on the other hand, plots receiving the highest level of P had the lowest weight of pods per plant Weight of pods per m2 increased with density (P / 0.001); at the lowest density, plots with no P had the lowest and those with highest level of P had the highest weight of pods. At the highest plant population, again the plots receiving the highest level of P had the lowest weight of pods per m2 (Fig. 2).

In the third experiment in the late season of 1975, P had no significant effect on growth characteristics except weight of haulms which was increased (P / 0.01) linearly as P level was raised from 0 – 90 kg P_2O_5 ha^{-1} (Table 4). Density also had effect on days to flower, weight per pod, weight of seeds per pod, weight of 100 seeds, shelling percentage and harvest index. The weight of haulms and total dry matter yield increased up to the highest level of plant population tried (Table 4). Number and weight of pods per plant decreased

TABLE 1: EFFECT OF PLANTING DENSITY ON FLOWERING AND YIELD COMPONENTS OF COWPEA (1974)

Density (Plants ha^{-1})	Days to 10% Flowering	Pod weight (g)	Weight of seeds/ pod (g)	Weight of 100 seeds(g)	Shelling Percentage	Weight of haulms (kg/ha)	Total dry matter yield (kg/ha)	Harvest index
37,000	40.2	1.10	0.68	12.0	62.7	752.5	1318.1	0.26
60,000	40.8	1.19	0.90	12.78	76.1	764.5	1452.3	0.36
99,000	40.0	1.14	0.84	12.89	73.5	1010.3	1962.4	0.36
125,000	40.3	1.25	0.93	12.0	74.5	1156.5	2239.6	0.35
154,000	40.3	1.24	1.03	11.89	83.0	1383.9	2429.6	0.36
222,000	40.4	1.55	0.94	12.22	77.3	1393.7	2545.3	0.35
Significance	*	NS	**	*	***	***	*	***
SE $\pm$	0.20	0.218	0.083	0.447	4.16	172.4	456.27	0.021

NS = not significant at P = 0.05; $^*P < 0.05$;
** $P < 0.01$; *** $P < 0.001$.

TABLE 2. EFFECT OF PLANT DENSITY ON FLOWERING AND YIELD COMPONENTS OF COWPEA (1975 EARLY SEASON).

Density (Plants ha^{-1})	Days to 50% Flowering	Weight (g) of 100 seeds	Shelling Percentage	Weight of haulms (kg/ha)	Total dry matter yield (kg/ha)
37,000	40.1	10.1	63.4	988	2071
60,000	39.3	10.3	61.7	1487	2884
99,000	39.9	10.4	58.2	1326	3372
125,000	40.1	10.2	61.9	1847	3517
154,000	40.1	10.4	61.2	1885	3664
222,000	40.2	10.2	58.9	4353	2489
Significance	*	NS	NS	***	***
SE±	0.25	0.23	2.75	147.4	326.6

NS = not significant at P = 0.05; * $P < 0.05$; *** $P < 0.001$

TABLE 3. EFFECTS OF PLANTING DENSITY AND P APPLICATION ON WEIGHT PER POD, WEIGHT OF SEEDS PER POD AND HARVEST INDEX OF COWPEA (1975 EARLY SEASON).

Density (Plants ha^{-1})	Weight/pod (g)				Weight of seeds/pod (g)				Harvest index			
	P_2O_5 (kg/ha)				(P_2O_5 (kg/ha)				P_2O_5 (kg/ha)			
	0	45	90	Mean	0	45	90	Mean	0	45	90	Mean
37,000	1.24	1.21	1.25	1.23	0.78	0.71	0.85	0.78	0.31	0.33	0.34	0.33
60,000	1.16	1.35	1.21	1.24	0.69	0.79	0.81	0.76	0.28	0.30	0.32	0.30
99,000	1.12	0.96	1.30	1.13	0.70	0.59	0.69	0.66	0.34	0.34	0.31	0.33
125,000	0.95	1.51	1.08	1.18	0.61	0.91	0.67	0.73	0.32	0.34	0.23	0.30
154,000	1.16	1.12	1.10	1.13	0.72	0.60	0.76	0.69	0.30	0.27	0.32	0.30
222,000	1.15	1.08	1.14	1.12	0.70	0.62	0.65	0.66	0.36	0.26	0.20	0.27
Mean	1.13	1.21	1.18		0.70	0.70	0.73		0.32	0.31	0.29	
SE±												
P Means	0.050 NS						0.036 NS			0.016 NS		
Density means	0.071 NS						0.051 NS			0.023 NS		
Interaction	0.123 **						0.089 *			0.039 *		

NS = not significant at P = 0.05; *P∠0.05; ** P∠0.01

TABLE 4. EFFECTS OF PLANTING DENSITY AND P APPLICATION ON WEIGHT OF HAULMS AND TOTAL DRY MATTER YIELD (1975 LATE SEASON).

	Weight of haulms (kg/ha)				Total dry matter yield (kg/ha)			
	P_2O_5 (kg/ha)				P_2O_5 (kg/ha)			
Density (Plants ha^{-1})	0	45	90	Mean	0	45	90	Mean
37,000	651.2	513.6	759.3	641.4	1114.8	1006.8	1243.9	1121.8
60,000	557.1	770.1	579.2	635.5	1202.0	1417.4	1187.5	1269.0
99,000	802.8	1039.2	958.0	933.3	1360.6	1734.3	1790.9	1628.6
125,000	735.8	1166.3	1238.9	1047.0	1536.5	2001.2	2052.9	1863.5
154,000	889.2	1024.6	1166.5	1026.8	1582.7	1889.2	2057.2	1843.1
222,000	937.7	1092.6	1379.1	1136.5	1988.5	2091.6	2394.9	2158.3
Mean	762.3	934.4	1013.5		1464.2	1690.1	1787.9	
SE±								
P means		86.13	**			247.66	NS	
Density means		121.81	***			350.25	*	
Interaction		210.97	NS			606.65	***	

NS = not significant at P = 0.05, * $P < 0.05$, ** $P < 0.01$ *** $P < 0.001$

with density but the pattern was not as consistent as in the first two experiments. Number of pods, weight per m2 and grain yield increased (P / 0.001) with increase in plant populations (Fig. 3) as in the other experiments. There was significant P x density interaction (P / 0.01) for total dry matter yield. At the low plant densities, there was no consistent pattern but at the high densities (125,000 plants ha^{-1} and above) there was linear response to P application (Table 4).

Discussion

There was increasing response up to the maximum density tried in this study. This type of response was referred to by Holliday (1960) as fitting into an asymptotic curve as opposed to a parabolic curve in which a certain plant population gives a maximum yield while greater or less populations give lower yields. The cowpea cultivar (Prima) used gave increasing yield with density probably because it is an erect and determinate type and more importantly, it produced few branches. A plant with such morphology would be less affected by intraspecific competition as shading is minimal even at dense stands. It is obvious from this study that with more plants per unit area at higher density with a plant type that is low branched, there is more leaf area for photosynthesis and more rapid accumulation of dry matter in all plant parts. Similar results have been reported by various workers. For instance, Ezedinma (1974) found that at close spacing there was increase in dry matter accumulated per m2 in the various parts of cowpea tops until harvesting. Kueneman, Bravo and Wallace (1978) found that narrow between row spacings (50cm) tended to give higher yields than wide (75 cm) spacings for beans with different habits. Nangju (1973) reported greater response to high densities with erect cowpeas than semi–erect ones.

In all three experiments, number and weight of pods per plant decreased with increase in planting density (Fig. 1 – 3). Plant size is usually larger with sparse density (Donald, 1963) and hence yield and its components per plant are expected to be greater. It is possible that the decrease in plant size in dense stands is a reflection of the activity of the root system which may be reduced with increasing density (Deschenes, 1974).

P effects were not very pronounced in this study. In the early season of 1975, P application increased days to 50% flowering due to enhanced vegetative growth. P application generally increased weight of haulms and total dry matter production. Pods were heavier, weight of seeds per pod and harvest index greater at lower density with the application of high levels of P (Table 3). Moreover, at the lowest density, pod weight (Fig. 2) was greatest with the application of the highest level of P and least at the highest density with this application. These results indicate that there was more response to P at low plant population. Apparently competition for applied P was greater at dense plant populations that at sparse populations.

In 1975, when the trial was made in the early and late seasons, yield and its components were higher in the early season. Ezedinma (1966) made the same observations and indicated that this was due partly to higher leaf area development in the early season. Though yields are higher in the early than in the late season, the general observation is that the quality of the early season

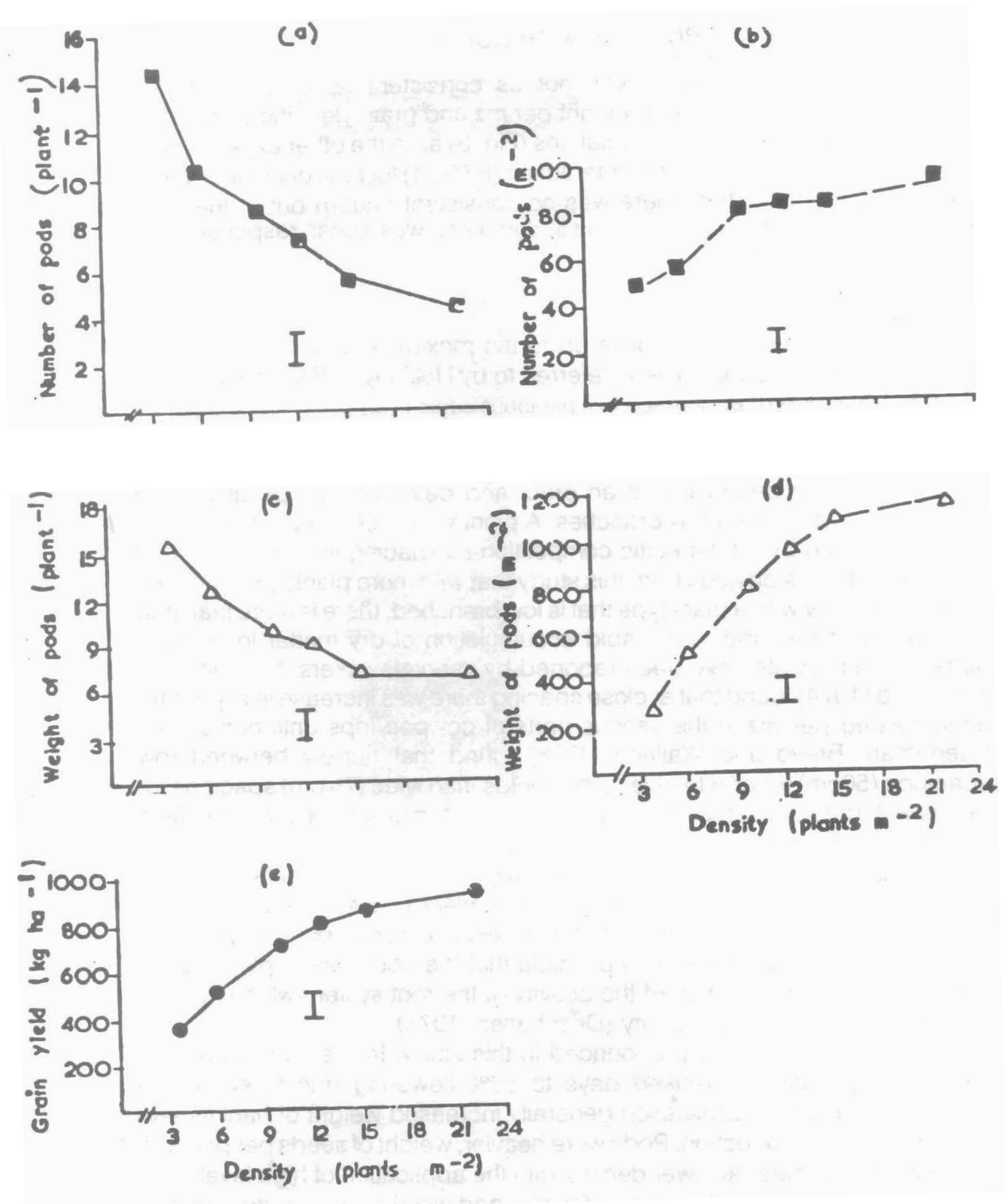

Fig. 1 The effect of planting density on (a) number of pods/plant, (b) number of pods/m^2, (c) weight (g) of pods/plant, (d) weight (g) of pods/m^2 and (e) grain yield of cowpea in 1974 experiment. Vertical bar represents standard error.

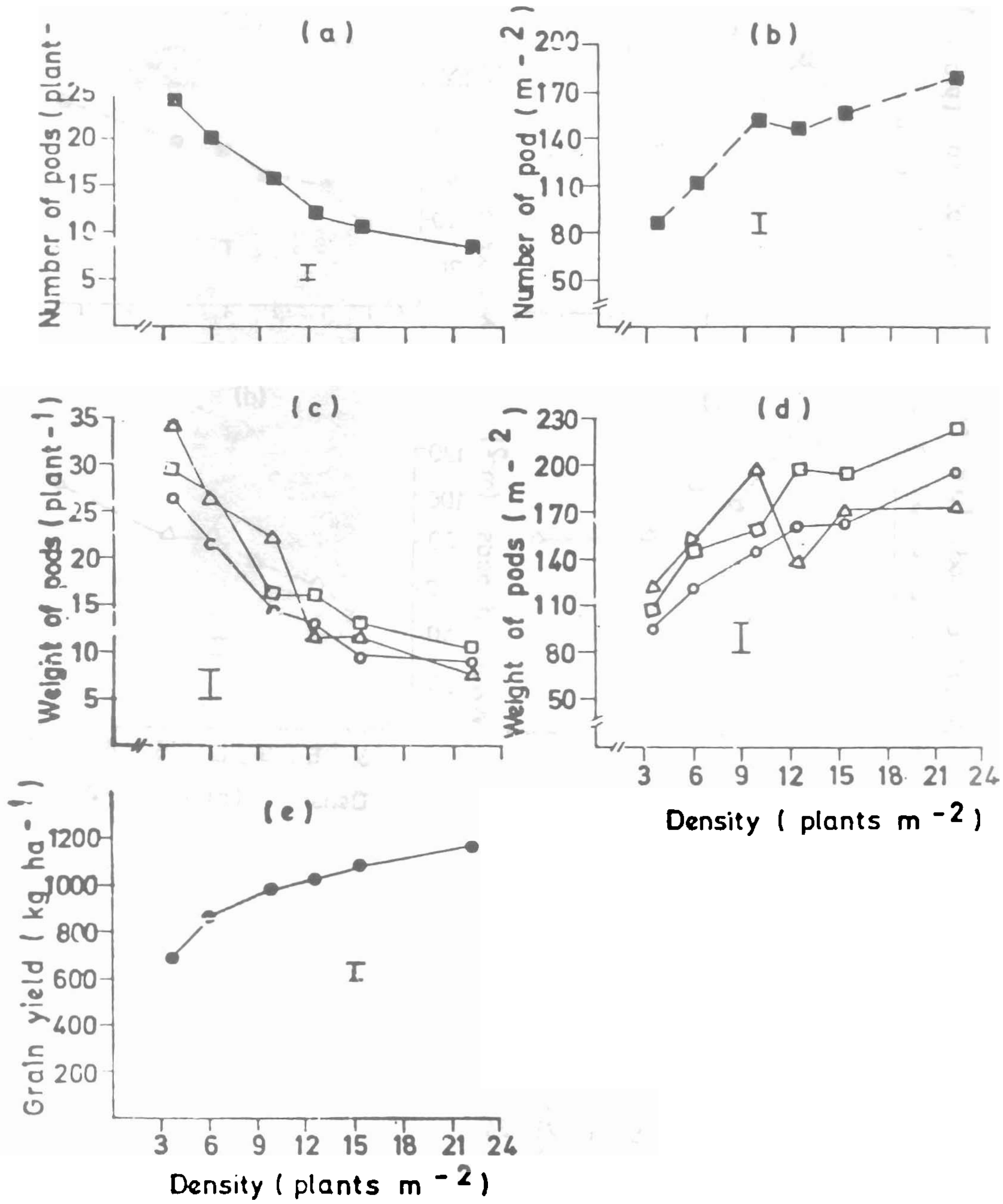

Fig. 2 The effect of planting density on (a) number of pods/plant, (b) number of pods/m² (c) weight (g) of pods/plant at nil (o), 45 ( ) and 90 ( ) kg P_2O_5 ha^{-1}, (d) weight (g) of pods/m² at nil (o), 45 ( ) and 90 ( ) kg P_2O_5 ha^{-1} and (e) grain yield of cowpea in 1975 (early season) experiment. Vertical bar represents standard error.

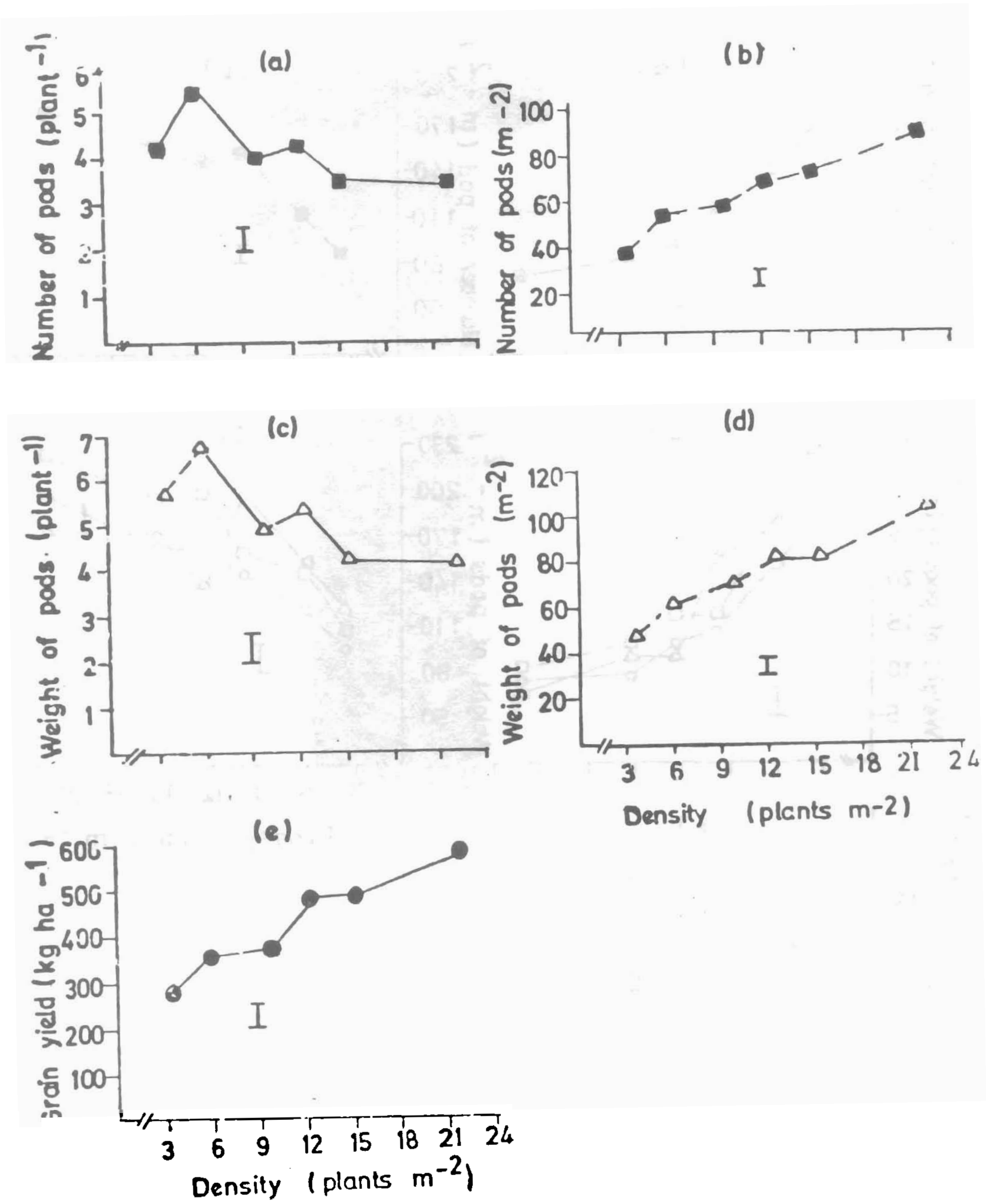

Fig. 3. The effect of planting density on (a) number of pods/plant (b) number of pods/m^2, (c) weight (g) of pods/plant, (d) weight (g) of pods/m^2 and grain yield of c cowpea in 1975 (late season) experiment. Vertical bar represents standard error.

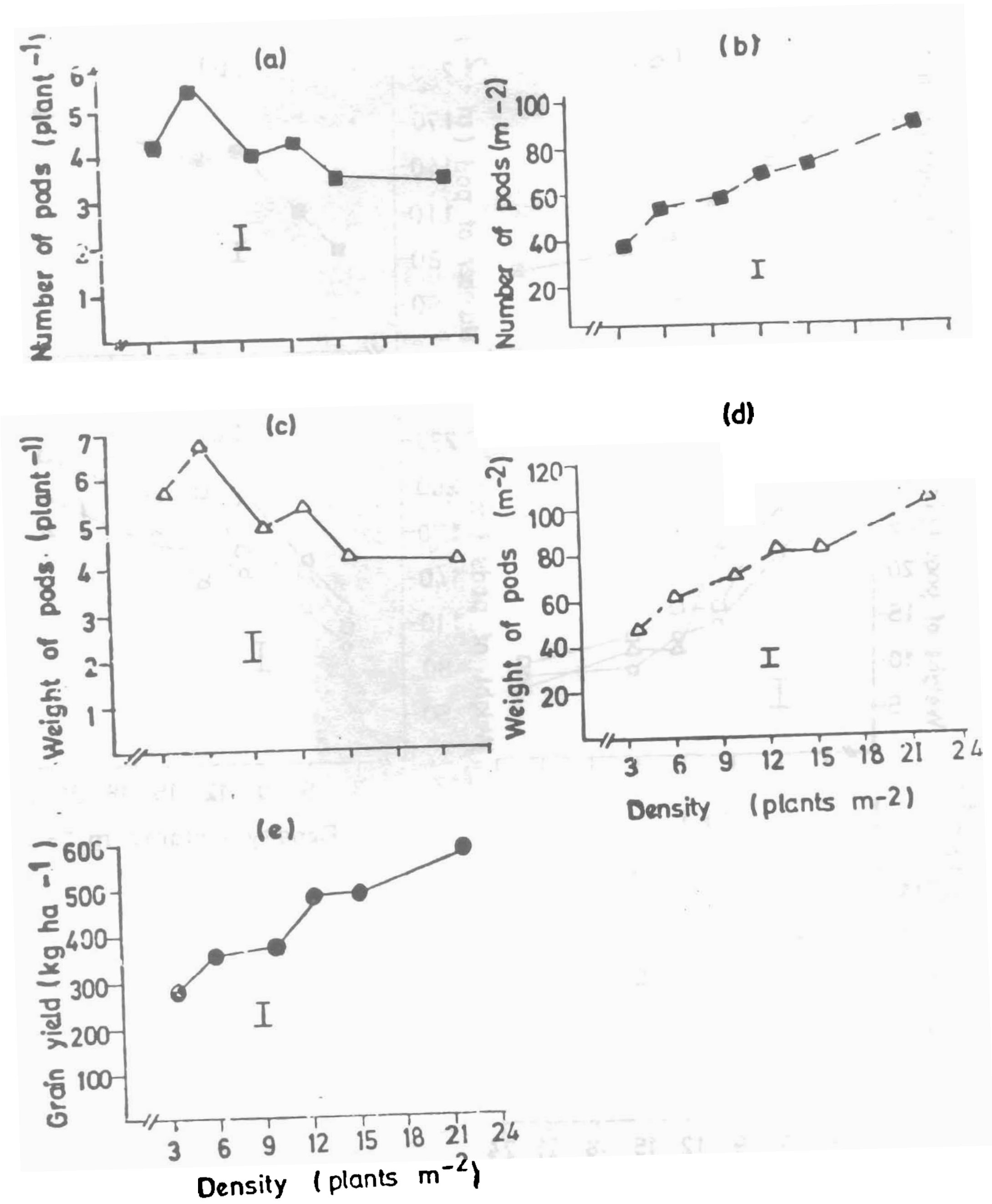

Fig. 3. The effect of planting density on (a) number of pods/plant (b) number of pods/m², (c) weight (g) of pods/plant, (d) weight (g) of pods/m² and grain yield of c cowpea in 1975 (late season) experiment. Vertical bar represents standard error.

crop is not as good as that of the late season because of more insect and disease infestation. Moreover there is lower solar radiation in the early season, resulting in mouldiness at the time of ripening. It is clear from the results in this study that erect cowpea varieties can be grown at high populations of 150,000 to 200,000 plants ha^{-1}

Acknowledgement

We are grateful to the Director of National Cereals Research Institute for permission to publish this work.

References

Akinola, J. O. and Davies, J. H. 1978. Effects of sowing date on forage and seed production of 14 varieties of cowpea *(Vigna unguiculata) Expl. Agric. 14:* 197 – 203.

Deschenes, J. M. 1974. Intraspecific competition in experimental populations of weeds. *Can J. Bot. 52: 1415 – 1421.*

Donald, C.M. 1963. Competition among crop and pasture plants. *Advan. Agron. 15:* 1 – 118.

Ezedinma, F.O.C. 1966. Some observations on the effect of time of planting on the cowpea *(Vigna unguiculata* (L.) Walp) in Southern Nigeria. *Trop. Agric. 43:* 83 – 87.

Ezedinma, F.O.C. 1974. Effects of close spacing on cowpea *(Vigna unguiculata)* in Southern Nigeria. *Expl. Agric. 10:* 289 – 298.

Holliday, R. 1960. Plant population and crop yield. *Nature 186: 22 – 24.*

Kueneman, E.A., Bravo, G.H. and Wallace, D.H. 1978. Effects of growth habits and competition on yields of dry beans *(Phaseolus vulgaris)* in the tropics *Expl. Agric. 14: 97 – 104*

Nangju, D. 1973. Progress in grain legume agronomic investigations at IITA, Nigeria. *Proc. 1st Grain Legume Workshop. 122 – 136.*

Ojehomon, O.O. and Bamiduro, T. A. 1971. The effects of plant density and pattern of plant arrangement on cowpea *(Vigna unguiculata L)* using parallel row systematic spacing design. *Niger Agric. J. 8:* 11 – 19.

Stewart, F. B. 1969. The effects of spacing and fertilization on yield of southern peas *J. Am. Soc. Hort. Sci. 94:* 337 – 338.

Tewari, G. P. 1965. Effects of N, P and K on nodulation in cowpea. *Expl. Agric. 1:* 257 – 259.