Effect of Spatial Arrangement on Growth and Yield of Cowpea in a Cowpea-maize Intercrop

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Summary

Cowpea growth and yield performance when intercropped with maize was studied for 3 consecutive seasons under three spatial arrangements, i.e., maize planted at 90 x 30, 100 x 27, and 120 x 22.5 cm, with 2 rows of cowpea between the maize rows. Growth and yield of cowpea was improved significantly by widening maize inter-row distances as compared to the 90 x 30 cm spacing.
Hence, intercropped cowpea needs to be sown where maize rows are wide apart, but the maize rows should not be too wide as this would lower the grain yield of maize.

Résumé

Effet des écartements sur la croissance et le rendement du niébé cultivé en association avec le maïs
La croissance et le rendement de deux variétés de niébé cultivées en association avec le maïs ont été étudiés pendant trois saisons consécutives en modifiant la densité de semis des deux composantes (deux lignes de niébé par ligne de maïs avec les densités de semis suivantes pour le maïs: 90 x 30 cm, 100 x 27 cm, 120 x 22,5 cm). La croissance et le rendement du niébé ont été significativement améliorés par l'augmentation de la distance entre les lignes de maïs comparé à l'écartement 90 x 30 cm. Les meilleurs rendements en niébé sont obtenus pour les écartements les plus élevés entre les lignes de maïs. Une trop grande augmentation de ces écartements risque cependant de se traduire par une diminution sensible de la production du maïs.

Introduction

Cowpea (*Vigna unguiculata* (L.) Walp) forms one of the major sources of proteins and revenues in many areas of the semi-arid tropics (4, 6). In Uganda, the crop is widely grown in the northern and eastern regions, but yields in the farmers fields are quite low (< 300 kg/ha). Many farmers grow cowpea in association with other crops especially maize, sorghum, greengram and cassava (1, 8). However, there is paucity of information about the appropriate spatial arrangements to achieve high yields. The objective of this study was to evaluate the effect of spatial arrangement on growth and yield of cowpea in a cowpea/maize intercrop.

Material and methods

Field experiments were carried out at Makerere University Agricultural Research Institute, Kabanyolo (32° 37'E, 0°28'N, 1200 m above sea level) and at Serere Agricultural and Animal Production Research Institute (33°27'E, 1°31'N, 1000 m above sea level) during the first (February- June) and second (September- December) seasons of 1996. It was repeated at Kabanyolo during the first rainy season of 1997.

Mean monthly rainfall during the first and second cropping seasons of 1996 averaged 159.3 and 138.2 mm for Kabanyolo and 246.7 and 144.1 mm for Serere. For the first season of 1997 at Kabanyolo monthly rainfall averaged only 96.8 mm. At both locations no fertilizer was added. Two cowpea varieties Ebelat (local) and an introduced variety IT82D-716 (from the International Institute of Tropicultural Agriculture, IITA, Ibadan) were planted as sole crops or intercropped with maize cv. Longe 1. The experimental design was a split-plot with varieties as the main-plots and spatial arrangements randomized as sub-plots.

The following spatial arrangements were investigated;

SA_1 – Maize planted at 90 x 30 cm with two rows of cowpea 40 cm apart planted between the maize rows. Thus, each cowpea row was 25 cm from the nearest maize row (8 cowpea and 5 maize plants/m^2, respectively).
SA_2 – Maize planted at 100 x 27 cm, with two rows of cowpea 40 cm apart planted between the maize rows. Each cowpea row was 30 cm from the nearest maize row (8 cowpea and 4 maize plants/m^2, respectively).
SA_3 – Maize planted at 120 x 22.5 cm, with two rows of cowpea 40 cm apart planted between the maize rows. Each cowpea row was 40 cm from the nearest maize row (8 cowpea and 5 maize plants/m^2).

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Field procedures and data collection and analysis basically followed those described by Obua *et al.* (6) for the cowpea-sorghum intercrop trial. Leaf area index (L.A.I.) and plant dry weight were determined for both sole and intercrop treatments at the vegetative, anthesis and pod/ear filling stages. Other variables measured included height of maize plants at maturity and number of branches per cowpea plant. Seed yield and yield components were also determined for both crops. For maize, the yield components measured included the number of kernels rows per cob, number of seeds per kernel row, 1000-seed weight and grain yield/6 m^2. Yield components were determined after sun drying the cobs to approximately 13% moisture content.

Land equivalent ratios were calculated to determine intercrop benefit (3). Analysis of variance (ANOVA) procedures using Mstatc computer programme (Russels O. Freed, Michigan State University, USA) and mean separation using LSD were the statistical tools (9).

Results and discussion

There was low and poorly distributed rainfall during the first season of 1997 (96.8 mm/month), causing failure of the maize crop. However, the cowpea crop still yielded relatively well. As such, discussions that follow are restricted to the two seasons of 1996 when successful growth of the two crops was achieved.

Spatial arrangements significantly (P= 0.05) affected both the growth and yield of cowpea. Highest L.A.I., branching habits and plant dry matter (DM) were obtained under SA_3, where the inter-row distance for maize were widest. SA_1 recorded the lowest L.A.I., DM/plant and fewest branches of cowpea (Tables 1 & 2). The wider inter-row distance between adjacent maize rows in SA_3 probably allowed more solar radiation to penetrate into the lower cowpea canopy as compared to SA_2 or SA_1 where the inter-row spacings for maize were narrower. There was no significant effect of the cowpea varieties on L.A.I., but variety x spatial arrangement interaction was significant at Serere during the first rains (Figure 1). For this season, there was higher L.A.I. at Serere than Kabanyolo because Serere experienced heavy rainfall which favoured more vegetative growth. Contrastingly, the relatively higher L.A.I. for cowpea at Kabanyolo than Serere during the second rains was due to the poor distribution of rainfall at Serere. As during the first season of 1996, varietal differences did not significantly influence the cowpea branching habits.

The effect of spatial arrangement was significant at both locations and during the two seasons of 1996. The spatial arrangement, in which the inter-row spacing for maize was the widest (SA_3) gave the highest number of cowpea branches. This was followed by SA_2, where the inter-row distance for maize was medium, and the least number of branches per plant was obtained with SA_1, in which the inter-row spacing for maize was the narrowest. Widening the inter-row spacings for maize seemed to provide adequate space and thus, enabled enough sunlight to reach cowpea, which in turn enhanced more branching of cowpea than under the narrower inter-row spacings. The highest numbers of branches per plant were obtained from the sole crop treatments compared to the intercrops. This probably indicated some degree of shading in the intercrop by the taller component crop, i.e., maize, which hindered the formation of many branches under the narrower spacings (SA_1 and SA_2).

Generally, as the distance between two adjacent maize rows was widened, there was a corresponding increase in the dry matter production in cowpea irrespective of the cowpea variety. The more branches of cowpea formed under wider inter-row spacings for maize must have contributed to the higher dry matter accumulation.

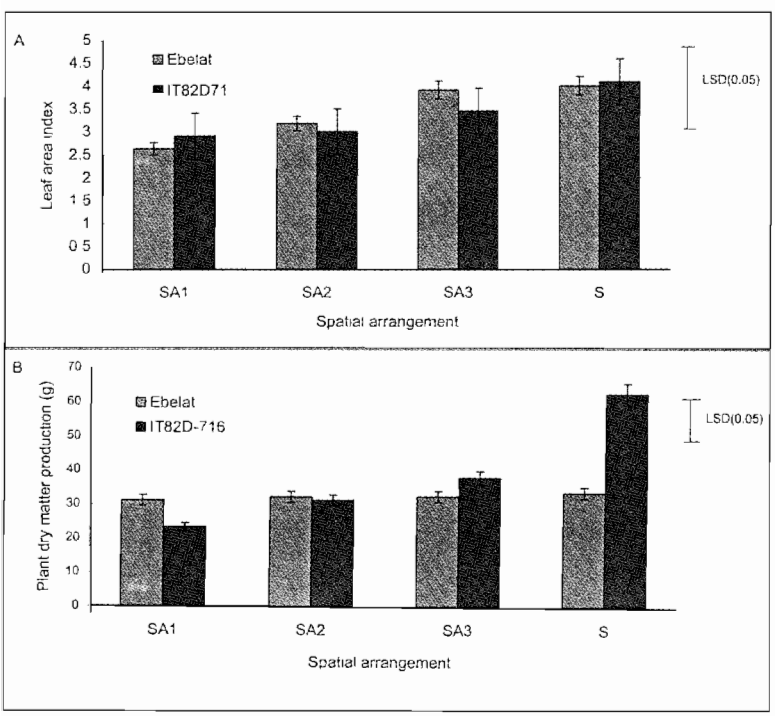

Figure 1: Effect of variety x spatial arrangement interaction on LAI (A) and dry matter production (B) of cowpea during the 1st rains.

IT82D-716 (V_2), however, showed a higher dry matter production in comparaison to the local variety, Ebelat (V_1) during the first rains both in the sole crop and when intercropped with maize but in the second rains, the reverse was true (Tables 1 & 2). There was, however, no statistical difference in dry matter production for the two cowpea varieties at Serere.

Grain yields very closely followed the growth trend. Highest number of pods/plant and grain yield (kg/ha) were obtained under the SA_3 spatial arrangement, and the lowest under the SA_1 arrangement (Table 3). The trend was similar for both Serere and Kabanyolo. Similar results were reported by Leihner (2). The higher grain yields under-wider inter-row spacing is attributed to the more branching achieved by cowpea due to less shading from the tall maize plants. Sole cowpea crops had the highest yield compared to those intercropped with maize, albeit the low cowpea population in the intercrop. However, higher grain yields were obtained from Ebelat than IT82D–716, at both locations, except at Serere during the second rains. The lower yield IT82D-716 during the second season at Serere was partly due to scab disease (data not presented) rather than

Table 1
Effect of spatial arrangements on growth of cowpea intercropped with maize

Treatments	L.A.I.	Branches/plant	DM/plant (g)
V_1 x SA_1	1.96	5.93	21.78
V_1 x SA_2	2.16	6.70	29.87
V_1 x SA_3	2.22	7.67	32.74
V_1 x S	2.73	7.00	43.52
Mean	2.26	6.83	31.98
V_2 x SA_1	2.11	6.40	25 .33
V_2 x SA_2	2.24	6.73	30.72
V_2 x SA_3	2.36	7.07	36 .97
V_2 x S	2.60	7.93	50.09
Mean	2.33	7.03	35.78
LSD (0.05)	0.23	0.78	4.62
C.V. (%)	5.55	6.35	7.68

V_1 = Ebelat; V_2 = IT82D-716
SA_1 = maize planted at 90 x 30 cm + 2 rows of cowpea between maize rows
SA_2 = maize planted at 100 x 27 cm + 2 rows of cowpea between maize rows
SA_3 = maize planted at 120 x 22,5 cm + 2 rows of cowpea between maize rows
S = sole cowpea

Table 2
Effect of spatial arrangements on growth of cowpea intercropped with maize

Treatments	L.A.I.	Branches/plant	DM/plant (g)
Kabanyolo			
V_1 x SA_1	1.95	11.93	38.26
V_1 x SA_2	1.89	11.73	40.28
V_1 x SA_3	2.01	14.73	49.97
V_1 x S	2.74	21.20	63.13
Mean	2.15	14.90	47.91
V_2 x SA_1	1.56	12.87	29.20
V_2 x SA_2	2.10	14.03	35.71
V_2 x SA_3	2.02	16.80	37.36
V_2 x S	2.87	22.40	61.21
Mean	2.14	16.53	40.87
LSD (0.05)	0.91	2.66	11.11
C.V. (%)	23.71	9.53	14.07
Serere			
V_1 x SA_1	1.29	8.50	24.38
V_1 x SA_2	1.52	8.16	32.10
V_1 x SA_3	1.58	11.17	40.63
V_1 x S	2.22	17.57	52.64
Mean	1.65	11.35	37.44
V_2 x SA_1	1.33	9.23	19.86
V_2 x SA_2	1.61	10.77	31.07
V_2 x SA_3	1.52	13.13	31.35
V_2 x S	2.53	18.27	51.52
Mean	1.75	12.85	33.45
LSD (0.05)	0.53	2.82	8.41
C.V. (%)	17.65	13.08	13.33

V_1 = Ebelat; V_2 = IT82D-716
SA_1 = maize planted at 90 x 30 cm + 2 rows of cowpea between maize rows
SA_2 = maize planted at 100 x 27 cm + 2 rows of cowpea between maize rows
SA_3 = maize planted at 120 x 22,5 cm + 2 rows of cowpea between maize rows
S = sole cowpea

solely to lower yield potential of this variety.
Cowpea yield was higher at Kabanyolo than at Serere (Table 4) during both the first and second growing seasons. The heavy rainfall at Serere during the first rains contributed to the excessive vegetative growth at the expense of reproductive growth. Secondly, the occurrence of scab disease during the first growing season at Serere lowered the grain yields. During the second

Table 3
Effect of spatial arrangement on the number of cowpea pods/plant when intercropped with maize

	Kabanyolo		Serere	
Treatments	1st rains	2nd rains	1st rains	2nd rains
V_1 x SA_1	24.60	13.50	11.77	13.50
V_1 x SA_2	27.87	30.93	12.50	14.63
V_1 x SA_3	28.27	40.73	14.20	15.93
V_1 x S	51.93	79.73	18.27	30.43
Mean	33.17	44.02	14.18	18.63
V_2 x SA_1	8.93	14.13	12.33	13.27
V_2 x SA_2	14.47	22.47	12.20	14.50
V_2 x SA_3	19.07	28.87	12.93	16.00
V_2 x S	31.67	62.73	15.80	40.70
Mean	18.53	32.05	13.32	21.12
LSD (0.05)	19.92	8.61	2.62	7.62
C.V. (%)	43.32	12.72	10.57	21.55

V_1 = Ebelat; V_2 = IT82D-716
SA_1 = maize planted at 90 x 30 cm + 2 rows of cowpea between maize rows
SA_2 = maize planted at 100 x 27 cm + 2 rows of cowpea between maize rows
SA_3 = maize planted at 120 x 22,5 cm + 2 rows of cowpea between maize rows
S = sole cowpea

Table 4
Effect of spatial arrangement on grain yields of cowpea (kg/ha) intercropped with maize

	Kabanyolo		Serere	
Treatments	1st rains	2nd rains	1st rains	2nd rains
V_1 x SA_1	888.39	525.56	187.67	975.00
V_1 x SA_2	832.78	892.78	197.56	1280.56
V_1 x SA_3	1126.28	1120.00	232.11	1500.00
V_1 x S	1619.39	2821.11	450.06	1425.14
Mean	1116.71	1339.86	266.85	1295.14
V_2 x SA_1	315.83	255.56	161.17	1308.33
V_2 x SA_2	403.50	662.78	169.56	1450.00
V_2 x SA_3	474.55	922.22	214.89	1552.78
V_2 x S	973.39	2551.11	247.00	1689.45
Mean	541.82	1097.92	189.15	1500.14
LSD (0.05)	432.67	598.00	107.63	325.83
C.V. (%)	29.33	27.57	26.02	13.11

V_1 = Ebelat; V_2 = IT82D-716
SA_1 = maize planted at 90 x 30 cm + 2 rows of cowpea between maize rows
SA_2 = maize planted at 100 x 27 cm + 2 rows of cowpea between maize rows
SA_3 = maize planted at 120 x 22,5 cm + 2 rows of cowpea between maize rows
S = sole cowpea

Table 5
Effect of spatial arrangement on the Partial and Total land equivalent ratios (LERs) of cowpea/maize intercrop

	First rains			Second rains		
	Partial LER		Total LER	Partial LER		Total LER
Treatments	Cowpea	Maize		Cowpea	Maize	
Kabanyolo						
V_1 x SA_1	0.55	0.87	1.42	0.19	0.80	0.99
V_1 x SA2	0.51	0.69	1.20	0.32	0.88	1.20
V_1 x SA3	0.70	0.83	1.53	0.40	0.80	1.20
V_2 x SA_1	0.33	0.76	1.09	0.10	1.17	1.27
V_2 x SA_2	0.42	0.93	1.35	0.26	0.95	1.21
V_2 x SA_3	0.49	0.80	1.29	0.36	0.97	1.33
Serere						
V_1 x SA_1	0.42	0.69	1.11	0.68	0.92	1.60
V_1 x SA_2	0.44	0.77	1.21	0.90	0.91	1.81
V_1 x SA_3	0.52	0.82	1.34	1.05	0.73	1.78
V_2 x SA_1	0.65	0.77	1.42	0.77	0.85	1.62
V_2 x SA_2	0.69	0.86	1.55	0.86	0.57	1.43
V_2 x SA_3	0.87	0.83	1.7	0.92	0.76	1.68

V_1 = Ebelat; V_2 = IT82D-716
SA_1 = maize planted at 90 x 30 cm + 2 rows of cowpea between maize rows
SA_2 = maize planted at 100 x 27 cm + 2 rows of cowpea between maize rows
SA_3 = maize planted at 120 x 22,5 cm + 2 rows of cowpea between maize rows
S = sole cowpea

rains, there was relatively poor distribution of rainfall at Serere which contributed to the low yield, but better yield of IT82D-716 as a result of absence of scab.
The LERs under the three spatial arrangements were greater than one (Table 5). This implied a yield advantage from intercropping cowpea and maize (5, 7), irrespective of the spatial arrangement. The highest yield advantage was achieved from SA_3, in which maize was planted at 120 x 22.5 cm, and the lowest was in SA_1 (90 x 30 cm). These results were independent of the seasons and locations.
The first rains recorded higher LER than the second rains at Kabanyolo as a result of greater contribution of cowpea (partial land equivalent ratio) to the intercrop system, while the reverse was true for Serere (Table 5). The first season at Serere was characterized by too much vegetative growth and scab epidemic which depressed cowpea yield. Cowpea recorded increased yields at Serere during the second rains and this increased its partial LERs, and hence, the total LER during the second season was higher than during the first season.
In conclusion, there was yield benefit from intercropping cowpea and maize for all the three spatial arrangements, but the yield benefit was greater under wide maize inter-row spacing, i.e., less competition for space between maize and cowpea. Similar results were reported on cassava/cowpea intercrop (2). Hence, to obtain higher yield of cowpea in a cowpea/maize intercrop, a spatial arrangement under which maize rows are wide apart would be ideal as this would allow adequate radiant energy to reach the cowpea canopy for growth and production. However, maize rows should not be spread very far apart as this would lower the yield of maize substantially. The successful growth of cowpea during the poor rainfall season of 1997, in contrast to total failure of the maize crop, explains why cowpea is a popular crop in the semi-arid tropics (4).

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