# Recovery of cotton (*Gossypium hirsutum*) from intercropping suppression by beans (*Phaseolus vulgaris*)

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ABSTRACT

The performance of cotton (cv. SATU-85) grown in five intercropping systems: cotton and beans (cv. K-20) planted simultaneously ($C_1L_1$); cotton planted two or four weeks prior to beans ($C_1L_2$ and $C_1L_4$); and beans planted two or four weeks prior to cotton ($L_1C_2$ and $L_1C_4$, respectively), was studied during the growing seasons of 1990 and 1993 in Uganda, and compared with monocropped cotton $C_1$, $C_2$ and $C_4$ planted on different dates at two-weekly intervals.

Intercropping significantly ($P < 0.05$) reduced cotton plant height, and number of monopodia and sympodia. At cotton picking time, after the bean harvest, no significant difference was observed in number of cotton bolls under the different cropping systems. Intercropping cotton simultaneously with beans increased the number of total fruiting positions (TFPs) compared with monocropped cotton. Seed cotton yields from the different cropping systems were 2045, 2250, 2220, 2691, 1982, 2036, 1708 and 2090 kg/ha for $C_1L_1$, $C_1L_2$, $C_1L_4$, $C_1$, $L_1C_2$, $C_2$, $L_1C_4$ and $C_4$, respectively. The highest land equivalent ratios (LER) occurred when cotton was planted two weeks after beans (1.71), four weeks after beans (1.53) and simultaneously with beans (1.32), whereas planting cotton two or four weeks before beans gave the lowest LERs (1.07 and 1.03 respectively). Intercropping cotton and beans is, therefore, advantageous only when cotton is planted either simultaneously or after beans.

## Introduction

Cotton (*Gossypium hirsutum* L.) an important cash crop in Northern and North-eastern Uganda, is frequently intercropped with beans (*Phaseolus vulgaris* L.), a very important crop in the region. Other food crops commonly intercropped with cotton are soybeans (*Glycine max.* L.), maize (*Zea mays* L.) and cassava (*Manihot esculenta Crantz*). The advantages of intercropping are claimed to include provision of favourable microclimate, better use of environmental resources, lower labour requirements, stability of yield and higher productivity per unit area (Osiru, 1982). However, the policies of the Ugandan Department of Agriculture discourages intercropping cotton. The effects of the associated crops on cotton yields have, therefore, not been quantified in Uganda.

The objective of the present research was to evaluate the performance of cotton when grown under different intercropping systems. The resulting information will be used to advise farmers of the advantages and disadvantages of intercropping cotton with food crops. This paper reports the results of a study carried out on cotton intercropped with beans, with the component crops being sown at different times.

## Materials and methods

Cotton (cv. SATU-85) was grown in 1990 and 1993 at Serere Agricultural and Animal Production Research Institute (SAARI), Uganda (33°27′E and 1°31′N; 1140 m ASL) either intercropped with beans (cv. K-20) or as monocrops. The climate is sub-humid with a mean rainfall of 1350 mm bimodally distributed, with a higher peak in



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April–May. There is a very hot dry season from December to March during which temperatures rise to a maximum of 35°C. The experiment was conducted in an area with shallow, brown sandy loam soil of a quartz-schist parental material.

SATU-85 is resistant to bacterial blight (*Xanthomonas malvacearum*), grows to a height of up to 2 m where fertility is high, and matures in 4–6 months, depending on weather. K-20 is an early maturing bean variety (80–90 days) which grows to a height of 45–60 cm.

Under intercropping, cotton was planted at the recommended inter-row spacing of 60 cm and intra-row spacing of 30 cm and later thinned to two plants per hill. Beans were interplanted alternating with the cotton rows and at intra-row spacing of 30 cm. As sole crops, cotton and bean rows were similarly spaced at 60 cm between rows and 30 cm within rows. The plants were thinned to two plants per hill. Details of the treatment combinations studied are given below.

$C_1L_1$: Cotton and beans interplanted simultaneously on 29th April

$C_1L_2$: Cotton planted on 29th April followed by beans two weeks later (15th, May)

$C_1L_4$: Cotton planted on 29th April followed by beans four weeks later (29th May)

$C_1$: Sole cotton planted on 29th April

$C_2$: Sole cotton planted on 15th May

$L_1C_2$: Beans planted on 29th April followed by cotton two weeks later (15th May)

$L_1C_4$: Beans planted on 29th April followed by cotton four weeks later (29th May)

$C_4$: Sole cotton planted on 29th May

Other treatments studied were sole bean stands $L_1$, $L_2$ and $L_4$, planted on April 29, May 15 and May 29, respectively, the results of which are not reported in this paper. Plots measured 4 m × 3 m and the experiment was a randomized complete block design (RCBD) replicated five times in each season.

Counting of bean pods was done at harvest time. The pods were picked, dried under the sun, threshed, sorted and grains weighed for final yield assessment. Beginning 60 days after the first planting (DAFP), data on cotton was recorded monthly for number of monopodia and sympodia; squares and flowers; and for bolls, up to the period when no more new bolls were formed. At this time, the total number of fruiting positions (TFP) were counted. Abortion of fruiting bodies was computed from the expression (TFP – TB)/TFP × 100% where TB is the total number of bolls that contributed to final seed cotton yield. All Cotton was picked at six months from planting date and seed cotton yield calculated.

Partial Land Equivalent Ratios (LER) for each of the crops under intercropping system was computed as a ratio of intercropped yields of that crop to that of its sole yields when planted on the same date. Total LER, as a measure of overall intercropping advantage (Willey, 1979) was taken as the sum of the two partial LERs.

## Results and discussion

Intercropping significantly ($P < 0.05$) reduced cotton plant height (Table 1). For the cotton planted on April 29, the reduction in plant height appeared to be directly proportional to the extent of competition to which cotton plants were presumably subjected. Competition was probably most intense in $C_1L_1$ and least in $C_1L_4$. Competition probably resulted in suppressed growth. Intercropping also significantly ($P < 0.05$) reduced number of both monopodia and sympodia in cotton planted on April 29 compared with their control, but the reduction was not significant in cotton planted on May 15 and 29 (Table 1).

For all cotton planted on April 29, intercropping with beans simultaneously increased the ability of the cotton crop to produce TFPs compared with the control and the cotton grown under $C_1L_2$ and $C_1L_4$ systems (Table 2). Similarly for cotton planted on May 15 and 29, intercropped cotton had more TFPs than their respective controls, but differences were not significant. It is probable that the residual nitrogen fixed by the bean crop benefited the cotton crop in this respect. Presumably, the nitrogen fixing ability of beans grown under intercropped systems, as measured by its effect on cotton TFPs in this case, tended to decrease with delay in bean planting. This might be used to explain the progressive decline of the TFPs in cotton grown under $C_1L_1$, $C_1L_2$ and $C_1L_4$, (318.3, 277.7 and 270.3, respectively). The apparent response of cotton to the fixed nitrogen tended to decrease with delay in cotton planting, which as a result emphasized more competition at early growth stages. This probably explains why TFPs for cotton grown under $L_1C_2$ and $L_1C_4$

**Table 1.** Effects of 8 cropping systems on cotton plant height and final number of monopodia and sympodia in 1993 at SAARI, Uganda

| Cropping system | Height (m) | Monopodia/m² | Sympodia/m² |
|---|---|---|---|
| $C_1L_1$ | 1.02c | 18bc | 93b |
| $C_1L_2$ | 1.07bc | 18bc | 92b |
| $C_1L_4$ | 1.22ab | 21ab | 98ab |
| $C_1$ | 1.29a | 23a | 107ab |
| $L_1C_2$ | 1.04c | 16c | 79cd |
| $C_2$ | 1.03c | 21ab | 90bc |
| $L_1C_4$ | 0.78d | 15c | 70d |
| $C_4$ | 0.98c | 19bc | 77cd |

Means in each column followed by the same letter(s) are not significantly different ($P < 0.05$, Duncan's Multiple Range Test).

systems were lower than their controls. Ewing (1918) and Wadleigh (1944) reported increased flowering and formation of fruiting bodies in cotton where nitrogen was applied.

Abortion of the fruiting bodies formed was significantly ($P < 0.05$) reduced with delay in cotton planting (Table 2). Intercropping did not affect abortion but the trend was towards reduced abortion with intercropping for cotton planted on April 29. This is contrary to Saleem and Buxton (1978) who reported high rates of abortion due to competition for the available plant carbohydrates, between vegetative and reproductive growth.

Generally, cotton from all the treatments except $C_1L_4$, $C_4$ and $C_2$ reached peak boll production in September (120 DAFP) and then levelled off (Table 3). Cotton from $C_1L_4$ showed a continuous trend in boll production and this could be ascribed to the continuous benefit from residual nitrogen of the later-planted beans which also imposed minimum competition. The increasing trend in boll production by $C_2$ and $C_4$ cotton is a normal phenomenon because these were plants growing without any interspecific competition compared with $L_1C_2$ and $L_1C_4$. The ability of $L_1C_2$ and $L_1C_4$ to produce more bolls was probably checked by the already vigorous bean plants. By time of last sampling, no significant difference was realized in boll numbers of cotton grown under the different cropping systems and planted on the same date. This illustrates the ability of early planted cotton to recover from intercropping suppression resulting from the component crop.

**Table 2.** Effects of 8 cropping systems on number of fruiting positions (TFP), abortion and seed yield of cotton in 1993 at SAARI, Uganda

| Treatment (kg/ha) | TFP/m$^2$ | Abortion (%) | Yield |
|---|---|---|---|
| $C_1L_1$ | 318a | 68.5ab | 2045bc |
| $C_1L_2$ | 278abc | 66.1ab | 2250b |
| $C_1L_4$ | 270bc | 67.8ab | 2220b |
| $C_1$ | 293ab | 69.8a | 2691a |
| $L_1C_2$ | 289ab | 63.1bc | 1982bc |
| $C_2$ | 243c | 59.3cd | 2036bc |
| $L_1C_4$ | 255bc | 56.7d | 1708c |

Means in each column followed by the same letter(s) are not significantly ($P < 0.05$) different (Duncan's Multiple Range Test).

**Table 3.** Effects of 8 cropping systems on cotton boll number/m$^2$ during 4 sampling dates in 1993 at SAARI, Uganda

| Cropping system | July | August | September | October |
|---|---|---|---|---|
| $C_1L_1$ | 5a | 48a | 51abc | 48ab |
| $C_1L_2$ | 3b | 37bc | 54abc | 52a |
| $C_1L_4$ | 3b | 31cd | 55abc | 57a |
| $C_1$ | 5a | 34bcd | 60a | 55a |
| $L_1C_2$ | 1c | 38bc | 57ab | 53ab |
| $C_2$ | 1c | 44ab | 48bc | 52ab |
| $L_1C_4$ | 0d | 16e | 44c | 43b |
| $C_4$ | 0d | 26de | 44c | 48ab |

Means in a column followed by the same letter(s) are not significantly ($P < 0.05$) different (Duncan's Multiple Range Test).

**Table 4.** Partial LERs for beans and cotton and total LERs for 5 intercropping systems in 1993 at SAARI, Uganda

| Intercropping system | Partial LER | | Total LER |
|---|---|---|---|
| | Beans | Cotton | |
| $C_1L_1$ | 0.56a | 0.76b | 1.32bc |
| $C_1L_2$ | 0.26b | 0.83ab | 1.09cd |
| $C_1L_4$ | 0.21b | 0.82ab | 1.03d |
| $L_1C_2$ | 0.74a | 0.97a | 1.71a |
| $L_1C_4$ | 0.71a | 0.82ab | 1.53ab |

Means followed by the same letter(s) are not significantly ($P < 0.05$) different (Duncan's Multiple Range Test).

Intercropping generally reduced seed cotton yields by the following percentages compared with the controls: 24.0, 16.4, 17.5, 2.7 and 18.3 for $C_1L_1$, $C_1L_2$, $C_1L_4$, $L_1C_2$ and $L_1C_4$ respectively. For cotton planted on April 29, the control yielded significantly ($P < 0.05$) better than the intercropped cotton (Table 2). However for cotton planted on May 15 and 29, yields of intercropped cotton did not significantly differ from their respective controls. Seed cotton quality was not affected by cropping systems and clean 'safi' cotton contributed, on average, 95% of total seed cotton yields.

Partial LERs for both cotton and beans were less than 1 (Table 4) indicating yield reductions of both crops under intercropped systems compared to under their respective sole stands. Intercropping systems $L_1C_2$, $L_1C_4$ and $L_1C_1$ resulted into relatively lower yield reductions for each of the component crops. These were the same treatments from which higher intercropping advantages were obtained as shown by total LER (Table 4).

## Conclusion

Beans and cotton can be successfully grown together either by first planting beans then following with cotton two or four weeks later, or by planting cotton and beans at the same time. All three of the above cropping systems allow cotton sufficient time to recover from the competition imposed by the beans before the onset of the peak reproductive growth. An additional advantage may be that cotton can utilise the nitrogen fixed by beans.

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## References

Ewing, E.C. (1918). A study of certain environmental factors and varietal differences influencing the fruiting of cotton. *Miss. Agr. Expt. Sta. Tech. Bull.* **8**.

Osiru, D.S.O. (1982). Intercropping: a review of the possible advantages. pp. 304–320 *In* Roy, S.K. (Ed.) Frontiers ofresearch in agriculture: *proceedings of the Indian Statistical Institute Golden Jubilee International Conference,* Calcutta.

Saleem, M.B. and Buxton, D.R. (1976). Carbohydrate status of narrow row cotton related to vegetative and fruit development. *Crop Sci.* **16**, 523–526.

Wadleigh, C.H. (1944). Growth status of the cotton plants as influenced by supply of nitrogen. *Ark. Expt. Sta. Bull.* **446**.

Willey, R.W. (1989). Intercropping—its importance and it's research needs. *Part 2. Agronomic Relationship. Field Crop Abstr.* **32**, 73–85.