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# The Effects of Nitrogen and Spacing on the Growth and Yield of Soyabean (*Glycine max.* (L) merr.) Under Coconut

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*Abstract* : The effects of nitrogen fertilizer application and spacing on the growth and yield of soyabean (cv. Bragg) grown as an intercrop under a mature stand of coconut in the intermediate zone of Sri Lanka during the north-east monsoonal rainy period are reported. Nitrogen had a significant effect on the seed yield and the number of pods per plant. The highest yield (447.8 kg ha$^{-1}$) and pod number were recorded at 33.6 kg N ha$^{-1}$. Nitrogen had no significant effect on plant height, nodule number, Leaf Area Index (LAI), dry matter yield, % protein and % oil in seeds, and yield components other than pod number. Closer row spacings had a significantly larger seed yield, LAI and dry matter yield than wowi der rspacings. Spacing had no significant effect on any of the other attributes studied.

## 1. Introduction

Soyabean with its many and varied uses is one of the most remarkable legumes, yet it is only within comparatively recent years that its real value has been fully recognised. The highly nutritious soyabean with high quality protein would prove to be the immediate answer to bridge the ever widening protein gap that exists in developing countries including Sri Lanka, due to the lack of cheap and readily available sources of protein. As a result of this tremendous potential, increased emphasis is placed on the cultivation of soyabeans.

In a coconut plantation planted at a spacing of 7.8 m x 7.8 m on the square system, during the juvenile stage and later under mature stands of over 30 years, sufficient light reaches ground level for satisfactory growth of an intercrop.[6] In such a palm-intercrop association there would be competition for soil moisture and nutrients if both or any one of them is in supply below the combined demand of the two crops.[6] Competition for plant nutrients can be minimised or avoided by independent application of fertilizer to both palm and intercrop, and competition for soil moisture between the palms and intercrops can be minimised or avoided by selecting the intercrops according to the rainfall pattern of the locality. On this basis, soyabean being a 3-4 month's crop is one of the most suitable crops that could be grown as an intercrop under coconut in the intermediate and dry zones of Sri Lanka during monsoonal rainy periods.

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Though there is ample information on the culture of soyabean as a monocrop[2,3,4,8] the same when it is grown in association with coconut is lacking. The general agronomic practices recommended for soyabean as a monocrop will not necessarily apply when it is grown as an intercrop. Nitrogen fertilization and spacing (plant density) are two important agronomic factors in the successful establishment of soyabean as an intercrop under coconut. This paper reports an investigation into the effects of varying the levels of nitrogen fertilizer application as well as spacing on the growth and yield of soyabean (*Glycine max* (L) Merr., cv. Bragg), grown as an intercrop under coconut during the North East monsoonal rainy period in the intermediate zone of Sri Lanka.

## 2. Materials and Methods

The experiment was conducted during the 1973/74 Maha season at Ratmalagara Estate, Madampe, N.W.P., under a mature stand of coconut (*Cocos nucifera* L. var. *typica*) of about 50 years old, planted on the square system of planting with a spacing of 9.0 m x 9.0 m. The experimental area had a very uniform soil which was a sandy clay loam with a dark grey brown top soil and a yellowish brown sub-soil with ironstone gravel and manganese nodules (A.S. Amarasinghe, personnal communication). It had a pH of 5.5 and 1105 ppm of total N. The weekly rainfall at the experimental site during the experimental period are summarised in Table 1.

TABLE 1. Weekly rainfall (cm) at the experimental site during the experimental period.

| Period | Total Rainfall (cm) | Period | Total Rainfall (cm) |
|---|---|---|---|
| 1 Nov. '73 — 7 Nov. '73 | 14.2 | 20 Dec. '73 — 26 Dec. '73 | 7.4 |
| 8 Nov. '73 — 14 Nov. '73 | 0.3 | 27 Dec. '73 — 2 Jan. '74 | 5.8 |
| 15 Nov. '73 — 21 Nov. '73 | 2.2 | 3 Jan. '74 — 9 Jan. '74 | 0 |
| 22 Nov. '73 — 28 Nov. '73 | 4.1 | 10 Jan. '74 — 16 Jan. '74 | 0 |
| 29 Nov. '73 — 5 Dec. '73 | 3.0 | 17 Jan. '74 — 23 Jan. '74 | 0 |
| 6 Dec. '73 — 12 Dec. '73 | 0.3 | 24 Jan. '74 — 30 Jan. '74 | 0 |
| 13 Dec. '73 — 19 Dec. '73 | 9.7 | | |

The experimental design was a split plot with 3 replicates. The main treatments were 5 nitrogen levels, 0, 11.2, 22.4, 33.6 and 44.8 kg $ha^{-1}$. Each main plot was 36 m x 9 m with a guard row of 3 m. Spacings of 37.5 x 7.5, 45.0 x 7.5, 52.5 x 7.5 and 60.0 x 7.5 cm formed the subtreatments, each subplot was 9 m x 9 m, i.e. one coconut square. A basal dressing of 67.3 kg $ha^{-1}$ of $P_2O_5$ and 44.8 kg $ha^{-6}$ of $K_2O$ in the form of concentrated super phosphate and muriate of potash respectively, were applied to each sub-plot on 2 November 1973. The seeds of soyabean (cv. Bragg) were innoculated with Nitrigin 'S' and planted in rows at a uniform within-row spacing of 7.5 cm with 2 seeds per hill on 3 November 1973. An area of 2 m radius from the base of

each palm was left unplanted. The stand was thinned to one plant per hill on 10 November 1973. Nitrogen was applied in the form of ammonium sulphate, half the total dose on 2 December 1973 and the other half on 2 January 1974. Prophylactic sprays of Malathion 50% at the rate of 25 ml in 4.5 litres of water were given at fortnightly intervals from 2 weeks after sowing. All plots were manually weeded on 24 November and 15 December 1973. 2.27 kg of C.R.I. 'C' fertilizer mixture (containing 5 parts by weight of ammonium sulphate (20.5% N), 2 parts by weight of saphos phosphate (12.0% P), and 3 parts by weight of muriate of potash (49.8% K) was broadcasted in the manure circle 1.65 m around the base of each palm and forked in[1] in late October before the commencement of the experiment.

The sampling procedure adopted was as follows. Each sub-plot of 9 m x 9 m was divided into two plots, each of 4.5 m x 9 m. One of them formed the sampling plot and the other the harvest plot. Ten plants were selected at random along the diagonals of each sampling plot. They were tagged and their heights were measured at 2, 4, 6 and 8 weeks after planting. On the same dates and at 10 weeks after planting ten more plants were selected at random along the diagonals of the sampling plot, they were uprooted and washed carefully, and observations on the number of root nodules were made. Leaf laminae of these plants were separated and the Leaf Area Index (LAI) was measured using the disc method[7]. The dry weight of tops were recorded after drying at 85°C in a ventilated dehydrator for over 36 hours. At crop maturity on 27 January 1974, from each harvest plot, 10 plants were selected at random along the diagonals and observations on number of podding nodes per plant, pods per plant and seeds per pod were made. The yield per harvest plot and weight of 100 seeds were also recorded. Percent crude protein and percent oil of the seed samples were determined using Kjeldhal method and Soxhlet method respectively.

## 3. Results

### 3.1 Seed yield and its components

Nitrogen had a significant effect on the seed yield ($P < 0.05$) (Table 2a). The highest yield of 447.8 kg ha$^{-1}$ was recorded at 33.6 kg N ha$^{-1}$ which was significantly superior to the yield at all the other nitrogen levels which were themselves not significantly different. Of the yield components, only the number of pods per plant was significantly affected by nitrogen application (Table 2a). The highest pod number per plant of 23 was again recorded at 33.6 kg N ha$^{-1}$ which was significantly greater than that at no nitrogen and 11.2 kg N ha$^{-1}$ ($P < 0.05$).

Seed yield dropped significantly from closer spacing of 37.5 cm (428.3 kg ha$^{-1}$) and 45 cm (426.2 kg ha$^{-1}$) between rows to wider spacing of 60.0 cm (328.7kg ha$^{-1}$) between rows ($P - 0.05$) (Table 2b). Spacing had no significant effect on yield components (Table 2b).

TABLE 2. The effect of (a) nitrogen application and (b) spacing on the ha$^{-1}$) and seed yield (kg its components of soyabean under coconut.

| | Nitrogen (kg ha$^{-1}$) | Seed yield (kg ha$^{-1}$) | Number of podding nodes/plant | Number of Pods/plant | Number of seeds/pod | 100 seed weight(g) |
|---|---|---|---|---|---|---|
| (a) | nil | 381.1 | 7.1 | 17.4 | 1.9 | 13.4 |
| | 11.2 | 384.5 | 7.4 | 17.7 | 1.9 | 14.0 |
| | 22.4 | 380.0 | 7.5 | 18.9 | 1.9 | 13.1 |
| | 33.6 | 447.8 | 7.7 | 22.7 | 1.9 | 13.8 |
| | 44.8 | 368.0 | 7.6 | 20.8 | 1.9 | 13.4 |
| | LSD(P = 0.05) | 49.9 | NS | 4.1 | NS | NS |
| (b) | Spacing/Plant density (cm) (plants m$^{-2}$) | | | | | |
| | 37.5x7.5/35.6 | 428.3 | 7.4 | 18.0 | 1.9 | 13.5 |
| | 45.0x7.5/29.6 | 426.2 | 7.4 | 19.2 | 1.9 | 13.8 |
| | 42.5x7.5/25.4 | 385.9 | 7.5 | 20.9 | 1.9 | 13.4 |
| | 60.0x7.5/22.2 | 328.7 | 7.5 | 20.0 | 1.9 | 13.4 |
| | LSD P= 0.05) | 84.6 | NS | NS | NS | NS |

Nitrogen x spacing interaction had no significant effect on either the seed yield or its components.

### 3.2 Composition of seed

Different nitrogen levels and different spacings and their interactions had no significant effect on the % crude protein and % oil of the seeds.

### 3.3. Nodulation

Neither nitrogen nor spacing had any significant effect on changing the nodule number of plants. The results showed considerable irregularity in the nodule counts obtained at different nitrogen levels.

### 3.4. Dry matter yield

Nitrogen had no significant effect on the dry matter yield at any stage. Dry matter yield generally increased with increase in nitrogen level up to 33.6 kg ha$^{-1}$ and then decreased (Table 3a).

Spacing had a significant effect on the dry matter yield at all harvests decreasing linearly as the spacing between rows increased i.e. as the plant density decreased (Table 3b). There were no significant nitrogen x spacing interaction at any harvest.

TABLE 3. The effects of (a) nitrogen application and (b) spacing on the dry matter yield ($gm^{-2}$) of soyabean under coconut.

| (a) Nitrogen (kg $ha^{-1}$) | Weeks atfer sowing | | | | |
|---|---|---|---|---|---|
| | 2(17/11/73) | 4(1/12/73) | 6(15/12/73 | 8(29/12/73) | 10(12/1/74) |
| nil | 6.3 | 24.0 | 89.9 | 156.8 | 227.7 |
| 11.2 | 5.7 | 23.3 | 87.4 | 147.1 | 193.4 |
| 22.4 | 6.5 | 31.3 | 99.3 | 192.3 | 170.1 |
| 33.6 | 7.2 | 30.8 | 123.8 | 188.3 | 184.0 |
| 44.8 | 6.2 | 27.1 | 108.9 | 196.9 | 243.4 |
| LSD (P = 0.05) | NS | NS | NS | NS | NS |
| (*b*) Spacing/Plant density (cm) (plants $m^{-2}$) | | | | | |
| 37.5x7.5/35.6 | 8.1 | 32.6 | 128.2 | 204.4 | 255.8 |
| 45.0x7.5/29.6 | 6.5 | 30.3 | 14.8 | 192.9 | 214.4 |
| 52.5x7.5/25.4 | 5.8 | 25.5 | 89.8 | 156.5 | 184.6 |
| 60.0x7.5/22.2 | 5.1 | 21.6 | 74.5 | 151.2 | 160.1 |
| LSD(P = 0.05) | 0.5 | 3.2 | 21.6 | 43.6 | 51.2 |

### 3.5. Leaf Area Index (LAI)

Nitrogen had no significant effect on the LAI at any stage of the experiment (Table 4a). At all nitrogen levels the maximum LAI was achieved at 6 weeks after planting. The highest LAI of 2.64 was recorded at 33.6 kg N $ha^{-1}$.

Spacing had a significant effect on the LAI at all harvests. The LAI increased significantly as the spacing between rows decreased, i.e. as the plant density increased (Table 4b). The highest LAI of 3.05 was recorded at the closest row spacing of 37.5 cm at 6 weeks after sowing. The interaction of nitrogen x spacing was significant at 6 weeks after sowing ($P < 0.05$), but no distinct trends were evident.

TABLE 4. The effects of (a) nitrogen application and (b) spacing on the Leaf Area Index of soyabean under coconut.

| (a) Nitrogen (kg $ha^{-1}$) | Weeks after sowing | | | | |
|---|---|---|---|---|---|
| | 2(17/11/73) | 4(1/12/73) | 6(15/12/73) | 8(29/12///73) | 10(12/1/74) |
| nil | 0.15 | 0.75 | 2.7 | 1.92 | 0.94 |
| 11.2 | 0.12 | 0.69 | 2.26 | 1.95 | 1.03 |
| 22.4 | 0.17 | 0.88 | 2.18 | 2.04 | 0.75 |
| 33.6 | 0.21 | 0.87 | 2.64 | 2.01 | 0.71 |
| 44.8 | 0.14 | 0.89 | 2.55 | 2.20 | 0.88 |
| LSD(P = 0.05) | NS | NS | NS | NS | NS |
| (b) Spacing/Plant density (cm) (plants $m_{-2}$) | | | | | |
| 37.5x7.5/35.6 | 0.20 | 0.99 | 3.05 | 2.59 | 1.12 |
| 45.0x7.5/29.6 | 0.17 | 0.96 | 2.54 | 2.17 | 0.95 |
| 52.5x7.5/25.4 | 0.14 | 0.70 | 2.08 | 1.90 | 0.75 |
| 60.0x7.5/22.2 | 0.11 | 0.61 | 1.69 | 1.52 | 0.63 |
| LSD(P = 0.05) | 0.04 | 0.19 | 0.37 | 0.38 | 0.35 |

### 3.6. Plant height

Nitrogen had no significant effect on plant height at the first and second harvests. Plant height increased significantly up to 22.4 kg N $ha^{-1}$ and then decreased, at 6 weeks ($P < 0.001$) and at 8 weeks ($P < 0.01$) after sowing (Table 5a).

Spacing had no significant effect on plant height at the first two harvests. However, closely spaced plants were taller than widely spaced ones at 6 weeks and 8 weeks after sowing ($P<0.05$) (Table 5b).

TABLE 5. The effects of (a) nitrogen application and (b) spacing on the plant height (cm) of soyabean under coconut.

| (a) Nitrogen (kg $ha^{-1}$) | Weeks after sowing | | | |
|---|---|---|---|---|
| | 2(17/11/73) | 4(1/12/73) | 6(15/12/73) | 8(29/12/73) |
| nil | 10.4 | 19.7 | 31.8 | 32.6 |
| 11.2 | 9.9 | 19.6 | 33.1 | 33.7 |
| 22.4 | 11.3 | 22.5 | 35.5 | 37.4 |
| 33.6 | 11.2 | 23.4 | 33.7 | 34.6 |
| 44.8 | 9.6 | 16.7 | 32.4 | 33.2 |
| LSD(P =0.05) | NS | NS | 1.2 | 1.9 |
| (b) Spacing/Plant density (cm) (plants $m^{-2}$) | | | | |
| 37.5x7.5/35.6 | 10.7 | 21.8 | 34.6 | 35.1 |
| 45.0x7.5/29.6 | 10.5 | 21.0 | 34.1 | 35.2 |
| 52.5x7.5/25.4 | 10.2 | 20.4 | 32.4 | 32.4 |
| 60.0x7.5/22.2 | 10.6 | 20.6 | 32.0 | 32.5 |
| LSD(P =0.05) | NS | NS | 2.0 | 2.1 |

## 4. Discussion

### 4.1. Seed yield

Nitrogen applied at the rate of 11.2, 22.4 and 44.8 kg $ha^{-1}$ did not have any significant influence on the seed yield, when compared with no-nitrogen plots. Only at 33.6 kg $ha^{-1}$ was there a significant increase in seed yield. The failure of response of nitrogen addition up to 22.4 kg $ha^{-1}$ in this study may have been due to the high soil nitrogen status (1105 ppm) and to the considerable amount of nitrogen supplied to the plants through the fixation process though the amount of nitrogen fixed was not measured. In this study there was considerable irregularity in nodule counts and as a result nitrogen had no significant effect on nodule number. Since nodule mass was found to be a better estimate of nodulation than nodule number,[2] and no nodule weights were taken in this study, nodule count alone does not possibly represent all

the effects of nitrogen on nodulation and nitrogen fixation. The failure of response to high nitrogen levels of 44.8 kg $ha^{-1}$ may probably have been due to the poor distribution of dry matter to the reproductive parts which was reflected in the drop in the harvest index from 24% at 33.6 kg N $ha^{-1}$ to 15% at 44.8 kg N $ha^{-1}$. The inability of inoculated soyabean to respond to high levels of nitrogen application has been reported by several workers.[2,3,8]

Significantly greater seed yields were obtained at the closer row spacings of 37.5 cm and 45.0 cm than at the wider row spacing of 60.0 cm (Table 2a). Lueschen and Hicks[5] found that increasing plant density in the range of 17.1 to 51.3 plants $m^{-2}$ had little effect on seed yield. The most common result reported by other authors[4,5] was that the yield components changed as a response to increasing density. In this study the fact that the yield components have not been affected by spacing i.e. plant density (Table 2a) indicates that the lower yields in wider spacings could be mainly attributed to the lower plant population and higher populations will have to be examined before an optimum could be arrived at.

### 4.2. Growth attributes

The maximum height was attained at 22.4 kg $ha^{-1}$, and the gradual decrease in height at higher nitrogen levels may have been due to the tendency of the plants to lodge in these treatments. The increase in plant height with decrease in spacing could be attributed to the tendency of soyabean plants to grow in search of limited sunlight under the shade of coconut.

High dry matter production and LAI were influenced mainly by spacing. Absence of response to LAI and dry matter yield to nitrogen application again indicates the nitrogen fixation by inoculated soyabeans at low levels of nitrogen and the failure of inoculated soyabean to respond to high levels of nitrogen application.

### 4.3. Suitability of soyabean as an intercrop for the intermediate zone

The mean yield of 392.3 kg $ha^{-1}$ is fairly low compared to the yields of over 1000 kg $ha^{-1}$ obtained from monocropped soyabean in other parts of Sri Lanka[2] (H. M. E. Herath, personnal communication). The lower yields realised in this experiment could be attributed to the severe moisture stress the crop experienced due to the lack of rainfall during the period of pod filling in early January (Table 1), aggravated by competition for the limited soil moisture available from the coconut roots, leading to a dropping of a large number of pods formed.

Short aged varieties of soyabean such as Bragg, mature in 3 months and as such could fit into the monsoonal rainy period in the intermediate zone of Sri Lanka if planted with the onset of rains.

However further experiments are needed on the time of sowing of soyabean in relation to the onset of monsoonal rains so as to coincide the pod filling stage with the tail end of the monsoons in order to minimise or avoid competition for soil moisture between the palms and the intercrop during this period and thus obtain high yields of soyabean under coconut.

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