Bean production in the lowland tropic with sub-irrigation

H. Aidar, M. Thung[1], J. Kluthcouski, I.P. de Oliveira. and J. L. D. Cabrera
Embrapa Arroz e Feijão. Cx. Postal 179. 75.375-000 Santo Antônio de Goiás. Brazil

The lowland tropics up to the 12° latitude South is one of the main irrigated rice production area in Brazil. Within this region about 2 million-hectare land can be sub-irrigated (irrigation by controlling the water-table through canal system) during the winter season, where soybean and maize are the traditional crops and water supply is not limiting. Excess water as well as with temporary water stress occur frequently, due to difficulties in managing the water table. Several farmers of this region plant bean in small-scale, using cultural practices and cultivars recommended for the Savannah. Observations showed that bean pods tend to set on the upper part of the plant and the internodes length is longer in this environment than in the traditional Savannah planting. Since the environment of the two ecosystems is very different, regarding temperature and water regime, it is necessary to develop appropriated cultural practices and cultivars. Many farmers would like to grow bean in this area as a new alternative, because bean price is always higher than maize or soybean. Unfortunately there is not sufficient information available for bean production under these agroclimatic condition.

The experiment for the lowland tropics region was carried out in COBRAPE farm in the State Tocantins (11° 26' 52.4'' S and 49 ° 57' 36.9''W at 115 m a.s.l.) and was designed to evaluate the effect of two spacing (45 and 90 cm between rows) and four plant densities (8, 12, 16, and 20 plant m^{-1}) using erect cv Ruda as a test plant. Internodes number and length on the main stem, position of the first pod and total pod per plant were measured. Yield and yield components were also analyzed in the two environments. Row spacing of 90 cm was chosen to exaggerate the effect of plant spacing on parameters mentioned above. The treatment with 45 cm row spacing and the 16 plant m^{-1} was compared to the experiment conducted in Savannah region at CNPAF/Goiania, in the State of Goias (16° 28' 28.4''S and 49° 17' 26.9''W with 700 m.a.s.l.). Both experiments were conducted during winter 1999.

The main climatic difference between the two regions is the temperature regime during the winter period. In COBRAPE (lowland tropics) the maximum and minimum temperature are 5°C above the Savannah region. The relative humidity, evapotranspiration and daylength are similar in both experimental sites (Table 1).

The soil of the sub-irrigated area is hydromorphic soil and the lower layer is poor sand with high water table. This caused the limited soil volume that can be exploited by the bean roots. The soil of the Savannah is a deep well structured Oxisol, but poor soil management has created a plowsole that impeded deep rooting in this region. The chemical characteristics of the two soils do not differ much, except that in COBRAPE the Phosphorus content is 14 times higher than in CNPAF (Table 2). Both experiments received 400kg ha^{-1} complete fertilizer type 4: 30: 16.

Bean yield is higher in the Savannah than in the lowland tropics, 3424 and 2078 kg ha^{-1}, respectively. The significant difference in pod number per plant and 100 seed weight contributed to this high yield. The number of nodes to the insertion of the first pod in the main stem is lower and its internodes length was significantly shorter at CNPAF than in COBRAPE. The high temperature, especially the high night temperature at COBRAPE is supposed to promote the elongation of the internodes. This explained the exuberant growth in the lowland tropics. The pod set at upper level of the plant suggested that the first flowers were not fixed due to flower-fall or not fecundated flower. On both locations the total number of internodes per plant (an average of 12.5 nodes per plant) and the number of seed per pod (average of 5.79) varied insignificantly, suggesting that both are genetically controlled (Table 3).

At COBRAPE farm by designed of the experiment, by increasing the spacing from 45 to 90 cm the plant population ha^{-1} will decrease by half at any plant density treatments. As the consequence, the yield decreased the yield accordingly. Increasing the spacing between rows did not change the position of the

[1] Supported by CNPq fellowship

first pod in the main stem, but neither increased the internodes length. The significant increase in 100 seed weight and number of pod per plant in plot with 90 cm spacing were not sufficient to compensate those yields on plots with 45 cm. Increasing the plant m^{-1} either in 45 or 90cm row spacing increased bean yield. Higher yields were obtained from plots with 12 plants m^{-1} or higher at both row spacing. Pod per plant and 100 seed weight were reduced with increasing plant m^{-1}. The average height of the first pod in the main stem was obtained at the highest plant m^{-1} (Table 4).

Bean production in lowland tropic is viable, provided the innovative cultural practices and adapted cultivars are planted.

Table 1. Climate characteristics of the two sites during the bean growth cycle, May - August (average of 19 years).

Location	Temperature °C			Rel. humidity (%)	Day length (hr)	Evapotranspiration(mm day^{-1})	Wind velocity (km hr^{-1})
	Max	Min.	Av.				
COBRAPE	34.3	20.3	27.3	62	11.6	4.5	n.a.*
CNPAF	29.5	15.5	22.5	56	11.2	4.1	3.6

n.a * data not available

Table 2. Soil characteristics of the experimental sites.

Location	Depth (cm)	pH (2:1)	$mmol_c\ L^{-1}$			$g\ kg^{-1}$					$g\ kg^{-1}$
			Ca	Mg	Al	P	K	Cu	Zn	Mn	O.M.
COBRAPE	0-10	5.45	36.3	16.6	4.3	67.4	158.0	2.6	2.0	20.0	41
CNPAF	0-20	5.65	21.5	13.2	1.3	4.05	120.3	3.4	3.1	45.8	16

Table 3. Position and height of the first pod insertion and yield component of cv. Ruda planted at COBRAPE and CNPAF.

Location	Plants ha^{-1} at harvest	Internodes $plant^{-1}$	Position of 1st pod	Height of internodes of the 1st pod (cm)	Pods $plant^{-1}$	Seeds pod^{-1}	100 seed weight (g)	Yield* (kg ha^{-1})
COBRAPE	268489	12.50**	5.95b**	23.50b**	10.15a**	5.76b**	16.63a**	2078a**
CNPAF	122897	12.75	3.35a	6.85a	14.15b	5.83a	18.13b	3424b

* Yield was taken from 7.2 and 10.0 m^2 for COBRAPE and CNPAF, respectively and yield component analysis was made from samples of 10 plants at CNPAF and 1.8m^2 at COBRAPE.

**Different letters within a column are significant different by LSD 5%.

Table 4. Yield and yield component of cv Ruda as affected by plant m^{-1} and spacing in lowland tropic.

Plant spacing/ density	Plants ha^{-1} at harvest	Pods $plant^{-1}$	Position of 1st pod	Height of internodes of the 1st pod (cm)	(Seeds pod^{-1}	100 Seed weight(g)	Yield* (kg ha^{-1})
Row 45 cm	268489	8.91a**	6.29**	25.66**	5.83b**	16.64b**	2156a**
Row 90 cm	133897	12.05b	6.28	24.41	5.75a	18.13a	1492b
8 Plant m^{-1}	127431	13.68a	6.25	23.65a	5.87	17.69a	1659b
12 Plant m^{-1}	191580	11.49b	6.13	24.44a	5.77	17.67a	1958a
16 Plant m^{-1}	228733	8.89c	6.21	24.68a	5.64	16.95b	1747ab
20 Plant m^{-1}	257031	7.86c	6.57	27.37b	5.88	16.40b	1933a

*Yield was taken from 14.4 and 7.2 m^2 and, yield component analysis was made on 3.2 and 1.8 m^2 for 45 and 90 cm row spacing, respectively. **Different letters indicate significant among means within a column at $P \leq 0.05$, according to LSD.