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PLANT POPULATION AND SPATIAL ARRANGEMENT STUDIES ON THE INTERCROPPING OF MAIZE AND BEANS (*Phaseolus vulgaris* L.) IN NORTHEAST BRAZIL[1/]

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SUMMARY

In Northeast Brazil the peasant farmers use to raise their crops in mixture, and the intercropping of maize and beans (*Phaseolus vulgaris* L.) is very frequent.

In order to examine plant populations and spatial arrangements of maize and beans intercropped, an experiment was carried out at Filadelfia, Brazil, located at 10°45' of south latitude and 40°07' of west longitude at 550 m altitude. The average annual rainfall of the area is 811 mm.

The statistical design was a randomized complete block with a split-plot arrangement, with four replicates. Four population levels of maize (25000, 50000,75000 and 100000 plants/ha) and beans (150000, 200000, 250000 and 300000 plants/ha) formed the main plots. The sub-plots were composed of five spatial arragements (pure maize, 1 M : 2 B, 1 M: 3 B, 1 M ; 4 B and pure beans).

It was concluded that the best spatial arrangement was 1 : 3, comprising 12,500 plants/ha of maize and 150.000 plants/ha of beans.

INTRODUCTION

Northeast Region occupies an area of 13% of the brazilian

1/ Paper prepared for the International Intercropping Workshop to be held at ICRISAT, Hyderabad, India, from January 10 to 13, 1979.

2/ Cropping Systems Agronomists of EMBRAPA/CPATSA (Brazilian Agriculture Research Corporation/Agriculture Research Center for Semi-Arid Tropics), Cx. P. 23, 56.300 - Petrolina, Pernambuco, Brazil.

territory and according to HARGREAVES (1974), half of this land is classified as semi-arid tropics. The brazilian semi-arid tropics are located between 3^o and 18^o south latitude and 35^o and 46^o west longitude, comprising an area of around 1,000,000 Km^2 including parts of the states of Maranhão, Piauí, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia and Minas Gerais.

According to BRASIL. SUDENE (1975), 73% of the holdings in Northeast Brazil have less than 50 ha and occupy 12% of the total area of the region. As shown in a survey carried out in the first 20 nuclei of "Sertanejo" Project[1/] by BRASIL. SUDENE (1977), the farmers can be classified as follows:

40% - Farmers without land
56% - Farmers having small properties
4% - Farmers having medium and large properties

At the present time, the cultivated land accounts for only 1/6 of the total area of the agricultural holdings (FRANCO, 1977).

In the northeastern region the small farmers normally manage a farming system involving small areas planted with food crops such as maize, beans, cassava, squash and fruits (banana or mango) and cash crops such as cotton and castor beans. Crop combinations vary with the region. Moreover, to complement their food or cash needs, they raise chickens, pigs, and goats. Until recently the research programmes devoted to the semi-arid tropics had not considered sufficiently the farming systems, and most research objectives had been to improve production techniques only for single crops or animal species, independently of each other (DILLON, 1978). Thus, it is an urgent need to spread the use of new technology emphasizing farming systems as a whole, and there is nobody better than the farmers themselves to provide the basis for this goal.

KRANTZ (1974) reported that two important factors, namely

1/ Government project to promote the development of typical holdings in the Semi-Arid Tropics of Northeast Brazil, leading to the minimization of drought effects.

climate and soils, have influenced farmers in developing their cropping patterns in the semi-arid tropics. The rainfall is erratic and undependable, so in a single cropping season it is possible to have excessive rainfall and droughts of short duration. The soils have a very low content of organic matter and native fertility. These factors connected with erratic and undependable rainfall pattern make crop production is semi-arid tropics a hazardous enterprise.

Limited capital resources and risk aversion of small farmers associated with other characteristics caused the early farmers in the semi-arid tropics to develop special cropping patterns based on multiple croppings, where more than one crop is grown on the same land in one year. In Northeast Brazil the most common situation is intercropping, where two or more crops are grown simultaneously on the same land in rows with definite patterns.

In terms of cropping combinations there are two clear situations in the semi-arid tropics of Northeast Brazil related to the rainfall regime. In regions with too erratic rainfall and limited suitability for rainfed agriculture, the most common combination is maize x beans (*Vigna unguiculata* (L.) Walp) x perennial cotton (*Gossypium hirsutum* L. var. "Maria Galante" Hutch.), with some variations for cassava, castor beans or palma (cactus for forage) (*Opuntia cochinellifera* Mill.). In regions with less erratic rainfall and a higher moisture availibility index (MAI) (HARGREAVES, 1974), there is a predominance of the combination maize x beans (*Phaseolus vulgaris* L.), with variations for cotton (*Gossypium hirsutum* L.) cassava or palma.

In Northeast Brazil some studies have been carried out on intercropping involving cereals and legumes (FARIS, 1976; ARAUJO, 1976 and LOPES, 1977), where the advantage of intercropping in relation to pure crops can be seen. However, in these studies the different aspects of plant population, proportional population and spatial arrangement have not been clearly distinguished.

This experiment was planned with the objective of studying these aspects in details.

MATERIALS AND METHODS

The experiment was carried out at Filadelfia county (State of BAhia), located at 10º45' south latitude and 40º07' west longitude, at 550 m altitude.

The soils of the area are deep eutrofic red yellow laterite with the following characteristics:

pH : 6.5

P_2O_5: 5.5 ppm

K_2O : 0.2 meq/100 g

O.M.: 0.8%

Al : 0.05 meq/100 g

The average annual rainfall is 811 mm, concentrated from November to July. A rain gauge, set up at the experimental site recorded 212.1 mm during the growing season (Figure 1).

The experimental area has an average slope of 8%. A system of ridges and furrows of 150 cm was prepared with three rows on the bed.

The statistical design was a randomized complete block with a split-plot arrangement, with four replicates. Four population levels of maize and beans formed the main plots. Each main plot was divided into 5 sub-plots composed of three different spatial arrangements of maize and beans, pure maize and pure beans.

The populations were distributed as follows:

Population	Maize	Beans
1	25,000	150,000
2	50,000	200,000
3	75,000	250,000
4	100,000	300,000

These populations were combined with the following spatial arrangements:

Pure maize (100%)

1:2 - 1 row of maize (33%) : 2 rows of beans (67%)

1:3 - 1 row of maize (25%) : 3 rows of beans (75%)

1:4 - 1 row of maize (20%) : 4 rows of beans (80%)

Pure beans (100%)

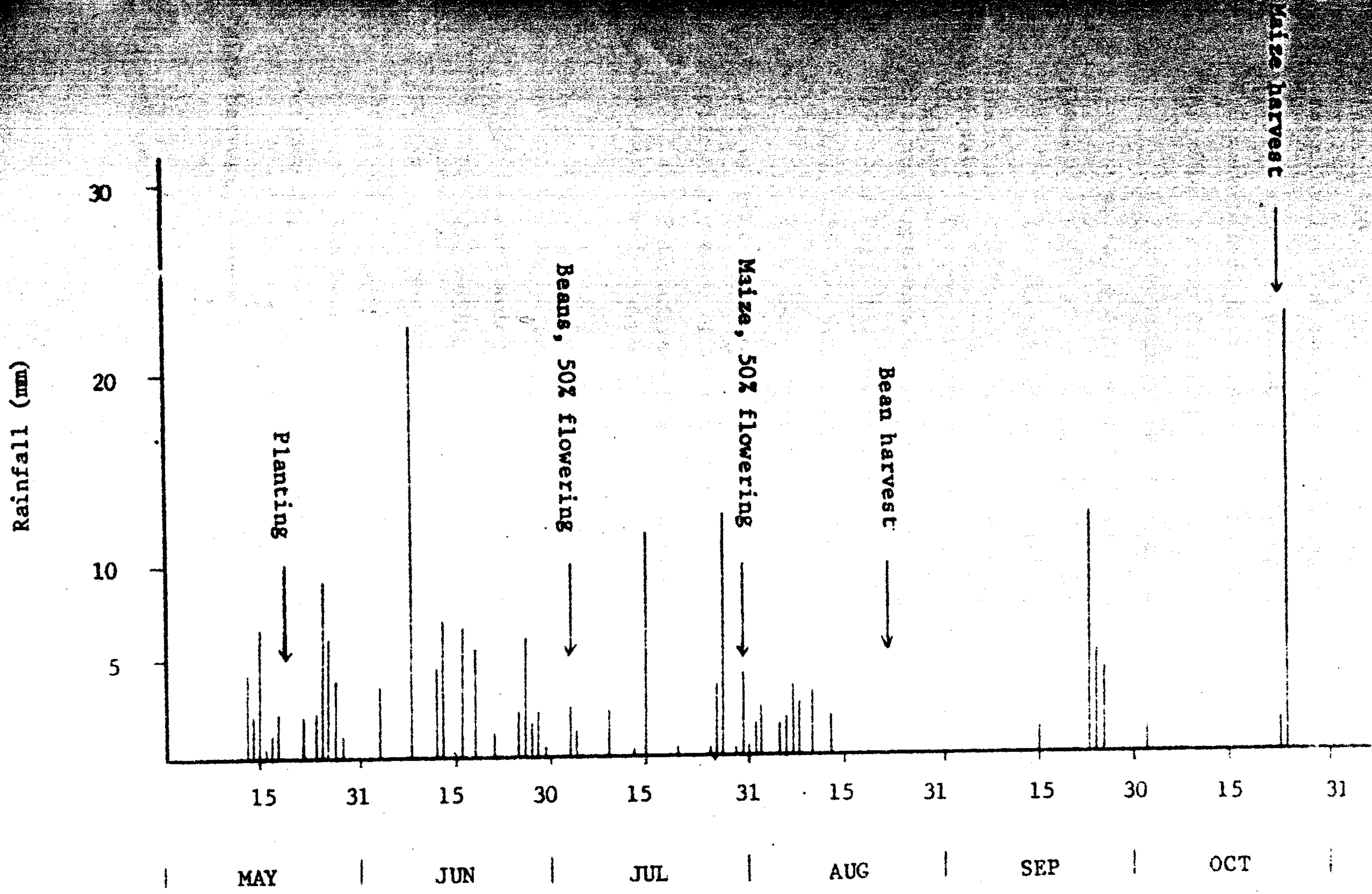

Figure 1. Phenological cycle of maize and beans intercropped, and rainfall distribution during the growing season. Filadelfia (Brazil), 1978.

The distance between rows was 50cm , except for pure maize where it was 1.00m. The different plant populations were obtained by using the row spacings of 80, 40, 26 and 20 cm for maize and 13, 10, 8 and 6,5 cm for beans, respectively. For pure maize the spacings were 40,20, 13 and 10cm.

At the planting time 20 kg/ha of N, 60 kg/ha of P_2O_5 and 30 kg/ha of K_2O were banded near the seeds. Fourty five days after planting 40 kg/ha of N was added as top dressing to maize.

The experiment was sown on May 19. Three seeds were placed in each planting hole, and plants were thinned to one plant per hill, 18 days after planting.

The variety of maize utilized was Centralmex, and the variety of beans was IPA 74-19, with a cycle of 150 days and 90 days, respectively.

During the growing period the crops were kept weed free and regular chemical sprayings were applied to control Spodoptera frugiperda (J.E. Smith, 1797) and Heliothis zea (Boddie, 1850) on maize, and Empoasca kraemeri Ross & Moore, 1957 on beans.

Each sub-plot of pure maize was planted with 5 rows, and the subplot of pure beans or maize x beans were planted with 9 rows, giving the following number of harvest rows for each crop:

Pure maize - Three central rows

1 M : 2 B - 1 row of maize and 2 rows of beans

1 M : 3 B - 1 row of maize and 3 rows of beans

1 M : 4 B - 1 row of maize and 4 rows of beans

Pure beans - three central rows

The moisture content of the seeds was determined at harvest time and corretion was made for 13% on beans and 15.5% on maize on a wet basis. The number of plants of each crop was counted within the harvest area.

The bean crop was harvested on August 22 and the maize crop, on October 23, 1978.

RESULTS AND DISCUSSION

Grain yields

Table 1 shows the grain yields in kg/ha for mixtures and pure crops at different populations levels. This is graphically shown in Figure 2. The statistical analysis indicated significant difference for spatial arrangement. There was significant difference for plant population in pure maize and mixture 1:3. There was no significant difference for population in the other mixtures.

The best yield advantages occurred at higher plant population levels (Table 1), which is in agreement with WILLEY (1972). According to DE WIT (1960), this situation takes place when the individual species utilize slightly different parts of the environment. For population 3 the best grain yields occurred in mixture 1:2, without significant difference for the mixture 1:3. In regard to population 4, the best grain yield occurred in mixture 1:2 differing statistically from other combinations.

It can be observed in Table 1 that the yield of pure maize decreased with the increase of plant population. The difference between population 1 and population 4 reached 46.2%. This fact is justified by high competition within the same species, causing a reduction of the cob index with an increase of the maize plant population, varying from 1.1 in a population of 25,000 plants/ha to 0.4 in a population of 100,000 plants/ha, as shown in Table 2. Table 2 also shows that the highest cob index occurred at lower population levels and in spatial arrangements with lower proportion of maize.

Pure beans showed a stable yield with maximum variation of 7.8% (Table 1). This situation could be due to the use of high plant population levels maintaining all grain yield at a population plateau. This result can be explained by the significant compensation effect of the number of pods per plant. That is, the lower population treatments produced in average 62.5% more pods per plant than the higher plant population (Table 3). It can be also seen in Table 3 that there was no significant difference for number of pods per plant among spatial arrangements.

Table 4 shows the land equivalent ratio (LER) and percentage of lodging in maize. Comparing yield data of Table 1 with LER and lodging of maize contained in Table 4, it can be seen that the LER of mixture 1:2 in population 4 presents a yield advantage of 28%, with a lodging in maize of

TABLE 1. Yield in kg/ha on the intercropping of maize and beans. Filadelfia (Brazil). 1978.

		Pure maize	1:2	1:3	1:4	Pure beans
Population 1	Maize	3753	1940	1361	966	-
	Beans	-	1344	1449	1576	1890
	Total	3753 Aa	3284 Aab	2810 Bbc	2572 Acd	1890 Ad
Population 2	Maize	3494	2250	2184	1698	-
	Beans	-	1083	1421	1536	2019
	Total	3494 ABa	3333 Aa	3605 Aa	3234 Aa	2019 Ab
Population 3	Maize	2904	2768	2473	1527	-
	Beans	-	1060	1233	1294	1862
	Total	2904 Bb	3828 Aa	3706 Aa	2821 Ab	1862 Ac
Population 4	Maize	2021	2852	1852	1384	-
	Beans	-	1051	1220	1286	1881
	Total	2021 Bcd	3903 Aa	3073 Ab	2670 Abc	1881 Ad

Within each column means not followed by the same capital letter, and within each row, means not followed by the same small letter, are significantly different at 5% level of probability as determinined by TUKEY test.

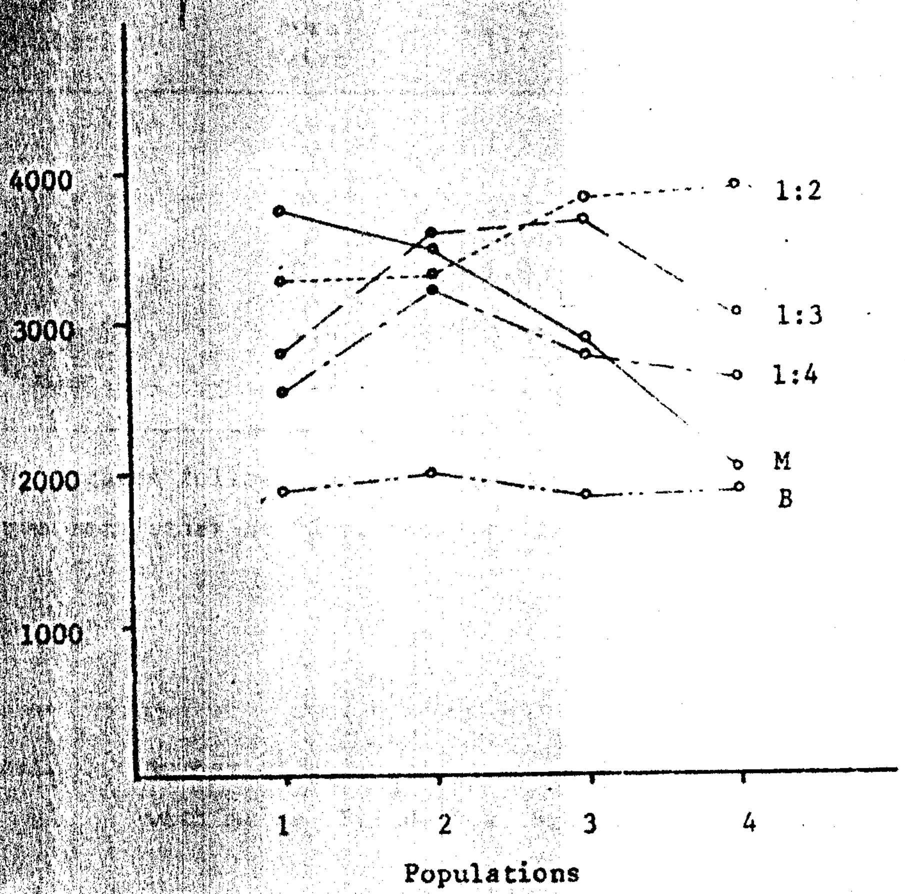

Figure 2. Total grain yield of mixtures compared with grain yields of pure crops at different population levels. (TUKEY at 5% within a given population: 682 kg/ha, C.V.$_{(a)}$: 16.1%, C.V.$_{(b)}$: 11.5%.

TABLE 2. Cob index in maize intercropped with Phaseolus vulgaris L. Filadelfia (Brazil), 1978.

Population	Pure Maize	1:2	1:3	1:4	Mean
1	1.1	1.5	1.6	1.6	1.4 a
2	0.8	1.2	1.4	1.5	1.2 b
3	0.7	1.0	1.1	1.2	1.0 b
4	0.4	0.8	1.0	1.1	0.8 c
Mean	0.7 c	1.1 b	1.3 a	1.3 a	

The figures followed by the same letters are not significantly different from each other at 5% probability level by TUKEY test.

TABLE 3. Number of pods per plant on Phaseolus vulgaris L. intercropped with maize. Filadelfia (Brazil), 1978.

Population	Pure Beans	1:2	1:3	1:4	Mean
1	16	17	15	15	16 a
2	14	11	13	12	12 b
3	12	12	11	11	11 c
4	11	10	10	10	10 d
Mean	13 a	12 a	12 a	12 a	

TABLE 4. Land equivalent ratio (LER) and percentage of lodging of maize plants on the intercropping of maize x beans. Filadelfia (Brazil), 1978.

Population	Pure maize		1:2		1:3		1:4		Pure Beans
	LER	Lodging	LER	Lodging	LER	Lodging	LER	Lodging	LER
1	1.00	12	1.18	3	1.02	2	1.04	17	1.00
2	1.00	56	1.14	10	1.28	12	1.21	4	1.00
3	1.00	65	1.27	23	1.27	16	1.05	15	1.00
4	1.00	97	1.28	45	1.09	25	1.01	21	1.00

45%. In population 2, of special note is the combination 1:3 where the LER indicates a yield advantage of 28% with a lodging in maize of 12%. In general, the percentage of lodging rose with the increase of plant population of maize, especially in pure maize treatments, reaching 97% at higher population level. This result is in accordance with FRANCIS and Associates (1976), in several experiments carried out at CIAT.

Competition between species

As shown in Table 1, in all population levels the bean yield increased as its proportion in the spatial arrangement increased. In the maize crop the situation was the opposite. In regard to the different population levels within each spatial arrangement the results show that the maize became increasingly competitive as population increased. These results are in agreement with those found by WILLEY (1972) and AIDAR (1978).

CONCLUSIONS

Considering the conditions at which the experiment was carried out, it can be concluded that:

1. Grain yield of pure maize decreased with the increment of plant population. However,, bean yield remained unchanged with the increment of plant population.

2. Total grain yields in mixtures gave better advantage at higer plant population levels, especially in the spatial arrangement of 1:2 and 1:3.

3. Considering the LER and percentage of lodging in maize the best spatial arrangement was 1:3, corresponding to 1 row of maize to 3 rows of beans, comprinsing 12.500 plants/ha of maize and 150.000 plants/ha of beans.

It is suggested a new trial to confirm the results reported.

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