GROWTH, YIELD AND SEED QUALITY OF CORN (*ZEA MAYS L.*) AND SOYBEAN (*GLYCINE MAX L. MERR.*) AS AFFECTED BY POPULATION DENSITY IN ROW INTERCROPPING

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Intisari

Suatu penelitian dengan percobaan lapangan, dilanjutkan dengan pengamatan laboratorium telah dilakukan untuk mengetahui pengaruh variasi populasi tanaman pada tumpang sari larikan jagung dengan kedelai terhadap pertumbuhan, hasil dan kualitas benihnya. Juga untuk dapat menentukan proporsi masing-masing tanaman dalam tumpangsari larikan yang terbaik, yang memberikan hasil dan kualitas benih yang memenuhi standar sertifikasi benih. Diharapkan cara ini dapat dipakai sebagai alternatif cara memproduksi benih, utamanya jagung dan kedelai.

Percobaan ini menerapkan rancangan acak lengkap berblok, dengan enam perlakuan, tiga ulangan, luas petak masing-masing 6 × 11 m^2.

Cara bertanam dengan tumpangsari larikan, ternyata mempengaruhi pertumbuhan tanaman kedelai dan hasilnya, namun tidak pada kualitasnya. Lebih sedikit populasi tanaman kedelai, menghasilkan tanaman lebih tinggi, umur panjang, hasil per tanaman lebih rendah dan sebaliknya. Benih kedelai berukuran besar, cenderung mempunyai kandungan protein lebih tinggi.

Pertumbuhan, pembungaan dan umur tanaman jagung, juga dipengaruhi sistem ini. Populasi tanaman yang lebih rendah, menghasilkan tanaman lebih pendek, umur lebih panjang, hasil per tanaman lebih tinggi, dan sebaliknya. Benih jagung berukuran besar cenderung mempunyai kandungan protein lebih tinggi. Proporsi benih besar, lebih tinggi pada populasi tanaman yang rendah.

Tumpang sari larikan dengan: satu larik jagung + empat larik kedelai; dua larik jagung + tiga larik kedelai, memberikan land equivalent ratio (LER) lebih dari 1.00. Kedua perlakuan di atas, merupakan dua yang terbaik di antara enam perlakuan yang ada dan diharapkan dapat sebagai alternatif cara memproduksi benih sebar.

Abstract

A study was conducted at the Central Experimental Station, UP Los Banos to investigate the effect of population density of corn and soybean planted in row intercropping on growth, yield and seed quality.

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Growth performance but not seed quality of soybean was affected by intercrops. Lower population density in intercrops produced taller plants with longer time to maturity. The higher population density in intercrops, yield of soybean per plant and per hectare basis was higher due to the higher number of nodes and pods per plant. Big seeds tended to have higher crude protein content than small seeds.

Plant height, days to tasseling, silking and maturity of corn were significantly affected by population density in intercrops. The lower density, produced shorter statures of plants but they took the longer time to tassel, silk and mature, higher seed yield per plant, but lower seed yield per hectare and a tendency for higher proportion of big seeds. The big seeds of corn tended to have the higher crude protein content, than the small seeds. No other physiological qualities of seeds were affected by intercropping.

Intercrops with one row corn and four rows of soybean, two rows of corn and three rows of soybean gave better yield than monocrop (land equivalent ratio LER more than 1.00).

Considering the seed quality and LER, the best intercropping proportions were: one row of corn and four rows of soybean; two rows of corn and three rows of soybean. These proportion can also be used as alternative method for seed production of corn and soybean seeds, particularly for extention seed for planting purposes.

I. Introduction

Internationally, corn is the second most important cereal grain, just after wheat and soybean is the largest grain leguma produced in the world (Bernard, 1976).

In many Asian countries, particularly in the Phillippines Indonesia, Malaysia and Thailand, corn is the second staple food and the major source of feed, while soybean is the major source of plant protein for human diet and for feed (Hakim, 1976: Cunard, 1976: Ballon and Resma, 1976).

These two crops are grown in monoculture or intercropped with other crops. Through intercropping, the land is utilized more intensively, resulting to the higher land equivalent ratio and gross return on investment (Beets, 1982). Aside from multiple harvests, additional advantages are minimal soil erosion and prolonged soil fertility (Ginting and Yusuf, 1983).

However, the production technology for soybean + corn intercropping has not yet been completely refined, hence this study. The occurrence of intra – and inter-spesific competitions in intercropping affects the growth and development of the crop components, e.g., plant height, days to flowering, maturity, yield components, yield and seed quality (Okigbo, 1975). One concept is that through row intercropping in which crop spacing is maintained, these competitions can be minimized.

There is a dearth of available data and verified information on the effect of intercropping on the seed quality of both corn and soybean. Findings could lead to appropriate recommendations for producers. The information is important in two ways. First, good quality seed stocks can be assured. In practice, many Asian upland farmers may not have the opportunity to renew their seed stocks due to their remote location from the sources of such sotcks and poor transport system. Secondly, good quality seed stocks can increase production and multiply economic benefits directly as well as indirectly.

II. Materials and Methods

A field experiment was done at the Central Experimental Station (CES) UP Los Banos to determine the influence of population densities in row intercropping on the growth yield and seed quality of corn and soybeans. Laboratory test for seed quality was conducted right after harvest.

Corn (IPB var 1) and soybean (UPLB Sy-2) were intercropped. Their Proportions, based on the number of rows in the same plor, constituted the six (6) different treatments, as shown in table 1. There was a gradation of 20 per cents between one treatment.

The six treatments were arranged following a Randomized Completely Block Design (RCBD) with three replications. The area experimental units was 6×11 m^2.

Observations were done mainly on agronomic parameters (e.g. plant height, LAI, LAR, NAR, CGR, days to flowering, days to maturity, yield components, yield, LER); seed quality (e.g. seed sizes proportion, seed germination and vigor, seed weight, cruse protein content). Laboratory test for particularly phisical and physiological quality of seed based on International Seed Testing Association (ISTA) regulation and procedures.

Data from the experiment were subjected statistical analysis. Analysis of variance was used to detect any significant differences among the results of the treatments. Comparison among treatments was performed by using Duncan's New Multiple Range Test (DMRT). Correlation analysis was also made computed following Gomez and Gomez (1984). Growth of plants were analyzed following the formula by Thorne (1960).

III. Results and Discussion

A. Agronomic Parameters

Population density in row intercropping affected some agronomic parameters on both corn and soybean. The data were presented in table 2.

The higher population of corn produsced the higher statures of plants may be due to sun light competition and the higher temperature inside the canopy. The activity of auxin may be promoted by the situation. It caused the shorter the number of days to maturity. On the other hand the soybean plants were affected by the partial shading from corn leaves, resulting in the taller plants under the higher population of corn and growth longer compared to the monoculture of soybean.

Crop growth rate of soybean plants were affected by intercropping, but not for corn, as shown in table 3.

Crop growth rate of soybean plants tended to be higher at the lower population of corn in intercropping, due to the lower partial shading by corn canopy, resulting in the sufficient sun light needed for fotosynthese. The lesser leaves at the last stage of growth (57 – 70) gave the CGR's were not significant among the treatments.

Row intercropping corn + soybean affected the Net Assimilation Rate of soybean but not for corn. The different intensity of shading due to the corn canopy gave the differrent NAR among treatment of soybean. The lower population or corn, resulting in the higher NAR for soybean, particularly at the later stages of growth, as shown in table 4.

Total dry matter of both corn and soybean were affected by row intercropping, mainly at the later stages of growth, as presented in table 5.

Dry matter production of soybean grown in monoculture was significantly higher than that intercropped with corn, particularly after 28 DAE. The higher NAR resulting in the higher TDM. Partial shading by corn canopy to the soybean leaves was the main cause of the lower NAR and TDM. The same finding was reported by Allen and Obura (1983) and Eriksen and Whitney (1984). On the other hand, TDM of corn tended to increase when the plants grown in intercrops with lower populations. It was due to the lesser intra-specific competition mainly for sunlight. Anwarhan (1977) and Saxena and

Chandel (1986) also showed that TDM corn per plant grown in intercrops was higher than those in monocrop, but TDM of the plants per hectare was lower due to the lesser number of plants.

Seed yield of both corn and soybean were affected by row intercropping due to the different population causing in the intensity in intra and inter-specific competition. The yields were in table 6.

B. Seed Quality

No physiological seed qualities were affected by intercropping, but some physical and chemical qualities e.g. seed sizes, crude protein content of seeds were affected. Table 7 presented the proportion of big seeds and the percentages of crude protein content of seeds.

Soybean seed proportion were affected by intercropping. The proportions of small and medium seeds were higher when harvested from intercrops, due to the higher interspecific competition particularly sunlight. On the other hand, the proportion of big seeds was higher in monoculture and in intercrops, when the population of soybean in intercrops were higher. While the proportion of corn seeds harvested from intercrops were different for big seeds, but not for small and medium seeds. The differences might be due to the interspecific-interaction in term of getting nitrogen nutrient, in intercropping. Stimulation occured due to the soybean plants excreted nitrogen which was then taken up by corn plants in association.

Crude protein content of soybean seeds, grown in intercrops, particularly for the big seeds were significantly different. The highest came from the treatment 4C1S. Apparently, the higher NAR at the final stage of growth resulted in the lower protein content and the lower NAR gave the higher protein content. Crude protein content of corn seeds was significantly different for big seeds. It shown that the seeds harvested from adjacent rows have higher CPC compared from the middle rows. It was also found that the correlation coefficient between CPC of corn and germination percentage was + 0.9347. This is similar to Kamal's (1953) on wheat seeds.

The higher yield seeds per plant of soybean particularly due to the higher number of node and pod. While for corn due to the longer of ear and the higher number of seed per row of seed resulting in the higher number of seed per ear. Intercrops gave no effect on hundred seed weight of soybean seed, but corn seeds was affected by intercrops. Seeds harvested from monoculture and from adjacent rows were found with the higher hundred seed weight.

IV. Conclusions

From the findings of the study, it can be concluded that: Most of agronomic characters of corn and soybean were affected by the population densities of each crop in association in row intercropping. Based on Land Equivalent Ratio, higher seeds yields were obtained from row intercropping with the folowing corn + soybean proportions: 40:60; 60:40 and 20:80. Seeds qualities, except seed sizes, hundred seed weight and crude protein content, were not affected by intercropping. Soybean seeds tended tobe smaller when intercropped with corn, while corn seeds tended to be bigger when intercropped with soybean. Crude protein content of soybean seeds tended to slightly increase under intercropping, the same as the corn seeds harvested from adjacent rows to soybean. Row intercropping with optimum spacings (6.25 $\times$ 75 cm^2 for soybean and 25 $\times$ 75 cm^2 for corn) can be used as alternative method for seed production using corn and soybean proportion at 20:80 and 40:60, particularly for extention seeds.

Table 1. **Six experimental population density treatments used for row intercropping corn + soybean.**

Treatment	Proportion of population densities				Total
	% corn	Pop'n	% soybean	Pop'n	
5C (all corn)	100	53 333	0	0	53 333
4Cls (four rows corn + one row soybean)	80	42 666	20	42 666	85 332
3C2S (three rows corn + two rows soybean)	60	31 999	40	85 333	117 332
2C3S (two rows corn + three rows soybean)	40	21 333	60	128 000	149 333
1C4S (one row corn + four rows soybean	20	10 666	80	170 667	181 333
5S (all soybean)	0	0	100	213 333	213 333

Table 2. **Plant height and days to maturity of corn and soybean grown in monoculture and intercropping.**

Treatment	Plant height (cm)		Days to maturity (days)	
	corn	soybean	corn	soybean
5C	156.5 a	–	91	–
4ClS	151.9 a	57.8 a	91 b	80 a
3C2S	147.0 bc	60.4 a	93 a	80 a
2C3S	141.5 bc	60.5 a	94 a	78 b
lC4S	138.4 c	49.1 b	94 a	77 bc
5S	–	53.6 ab	–	76 c
				SSD 5%

* each crop had separate statistical analysis.

Table 3. **Crop growth rate (CGR, g $m^{-2}d^{-1}$) of soybean grown in monoculture and intercropped with corn.**

Treatment	Growth Stage (DAE)				
	0 – 14	15 – 28	29 – 42	43 – 56	57 – 70
4C1S	0.82 b	5.83 a	8.05 c	13.20 b	5.24 a
3C2S	1.31 a	6.34 a	11.50 bc	12.64 b	6.77 a
2C3S	1.57 a	6.39 a	7.87 c	25.36 a	4.12 a
1C4S	1.29 a	3.45 b	15.55 a	20.30 ab	1.14 a
5S	1.42 a	5.44 a	12.92 ab	19.11 ab	3.21 a
*					
					SSD 5%

Table 4. **Net Assimilation Rate (NAR, g $m^{-2}d^{-1}$) of soybean grown in monoculture and intercropped with corn.**

Treatment	Net Assimilation Rate		
	15 – 28	29 – 42	43 – 56
4C1S	4.93 a	3.56 bc	4.67 b
3C2S	4.00 b	3.53 bc	4.03 b
2C3S	3.54 bc	2.21 c	6.83 a
1C4S	2.68 c	5.76 a	5.89 ab
5S	3.68 b	4.28 ab	5.83 ab
			SSD 5%

Table 5. **Total Dry Matter (TDM, g/plant) of corn and soybean grown in monoculture and intercropping.**

Treatment	Growth Stage (DAE)					
	14	28	42	56	70	84
			Soybean			
4C1S	0.54 b	4.37 a	9.67 c	18.33 b	21.11 b	
3C2S	0.86 a	5.02 a	12.58 ab	20.88 ab	25.33 ab	
2C3S	1.03 a	5.23 a	10.41 bc	27.07 a	29.77 a	
1C4S	0.84 a	3.12 b	13.33 a	26.66 a	26.66 ab	
5S	0.93 a	5.51 a	13.00 ab	25.55 a	27.66 ab	
			Corn			
5C	3.25 b	19.20 ab	51.11 a	92.55 ab	175.55 ab	194.22 b
4C1S	2.82 b	15.15 ab	46.77 a	93.44 a	142.77 b	228.88 ab
3C2S	2.49 b	20.00 a	53.33 a	83.33 a	171.66 ab	218.92 ab
2C3S	2.61 b	23.82 a	64.44 a	89.33 a	166.33 ab	204.77 ab
1C4S	5.18 a	13.25 b	57.77 a	86.22 a	192.44 a	256.55 a
					SSD 5%	

Each crop was subjected to separate statistical analysis.

Table 6. **Seed yields of corn and soybean grown in monoculture and intercrops and their LER.**

Treatment	Corn yield		Soybean Yield		LER
	g/plant	kg/hectare	g/plant	kg/ha	
5C	91.26 b	4848.58 a	–	–	1.00 a
4C1S	72.52 b	3950.88 b	5.93 b	253.51 c	0.94 a
3C2S	101.19 a	3238.17 c	6.80 b	581.19 c	0.97 a
3C2S	99.34 a	2119.27 d	9.31 a	1193.39 b	1.05 a
4C1S	119.82 a	1278.09 a	10.36 a	1769.20 a	1.18 a
5S	–	–	9.39 a	2003.36 a	1.00 a

Each data and crop had separate statistical analysis.

Table 7. **Big seed proportions (% by weight) and crude protein content (%) of corn and soybean grown in monoculture and intercropping.**

Treatment	Big seeds proportion (%)	Crude protein content (%)		
		SS	MS	BS
			Corn	
5C	12.07 ab	8.17 a	8.39 a	8.14 ab
4C3Sa	15.87 a	8.14 a	7.81 a	9.23 a
4C1Sm	9.89 b	7.43 a	7.72 a	7.91 b
3C2Sa	11.65 ab	7.92 a	8.22 a	8.56 ab
3C2Sm	11.32 ab	7.35 a	7.97 a	8.47 ab
2C3S	11.66 ab	8.14 a	8.37 a	8.18 ab
1C4S	15.39 a	8.56 a	8.93 a	8.22 ab
X	12.55	7.95 B	8.20 A	8.38 A
			Soybean	
4C1S	8.94 b	37.18 a	37.18 a	39.80 a
3C2S	13.19 ab	34.29 ab	36.55 a	37.81 abc
2C3Sa	11.97 b	34.68 a	33.95 a	37.82 abc
2C3Sm	12.71 ab	36.26 a	33.72 a	36.43 c
1C4Sa	12.18 ab	36.72 a	35.81 a	36.95 bc
1C45m	12.31 ab	36.74 a	33.76 a	39.12 ab
5S	16.35 a	30.74 b	34.39 a	38.51 abc
X	12.43	35.23 B	35.05 B	38.06 A
				SSD 5%

Each data and crops were analyzed separately.

SS = small seeds
MS = medium seeds
BS = big seeds a = adjacent rows m = middle rows

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