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Plant Performance on Several Maize-Soybean Intercropping Patterns Inoculated With Arbuscular Mycorrhizal Fungi and Organic Matter in the Suboptimal Land of North Lombok

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Abstract:- This study aims to determine the plant performance on several maize-soybean intercropping patterns inoculated with arbuscular mycorrhizal fungi (AMF) in the suboptimal land of North Lombok. This research was conducted from April to July 2019 in Balai Dana Of The Pemenang Barat Village, Sub-District Of Pemenang, North Lombok Regency. The experimental design used was Randomized Block Design (RBD) with the treatment of 5 intercropping patterns, namely: P $_1$ = 2 rows of maize : 2 rows of soybean , P $_2$ = 3 rows of maize : 2 rows of soybean , P $_3$ = 3 rows of maize : 3 rows of soybean , P $_4$ = 4 rows of maize : 2 rows of soybean , P $_5$ = 4 rows of maize : 3 rows of soybean . Each treatment was repeated three times so that 15 experimental plots were obtained. Observations were made on research variables which included number of leaves, plant height at 14, 40, 66 and 92 days after seeding (DAS), weight of root biomass and plant pods at 40 days after planting and 92 days after planting, weight of plant trimming, weight of maize cobs and soybean pods per plot and weight maize cobs and soybean per plant at 92 DAS. The results showed that plant height and leaf counts were mainly seen at the maximum vegetative age of the plant (66 DAS) in the treatment of intercropping composition of 3 rows of maize : 3 rows of soybean. Intercropping of 3 rows of maize : 3 rows of soybean (P3) aged 66 days after planting maize height reached an average of twice the height of soybean plants. If the number of rows of maize than 3 lines in added into 4 rows is the number of lines of soybean remain three rows , the result of the weight of root biomass wet and dry maize dropped 5-fold and 4-fold, while the weight of biomass wet and dry shoots down into 4 times and 5 times that. The appropriate planting density for maize-soybean intercropping in the suboptimal soil of North Lombok is 3 rows of maize : 3 rows of soybean. If the number of rows of maize from 3 rows is added to 4 rows while the number of rows of soybean remains 3 rows, the yield of wet and dry pods per soybean plot will decrease by 4 times.

***Keywords**: Plant Performance, Intercropping, Maize, Soybean.*

I. INTRODUCTION

The expansion of planting area can be cultivated on land suboptimal with planting maize and soybean intercropping. Extensive land areas suboptimal West Nusa Tenggara (NTB) the extent of 84% (1.8 million hectares) of land area that is 2.015 million hectares (Suwardji et al., 2007). From the area of dry land, there are about 749,000 hectares of potential to be developed into a productive agricultural land to maize plants that have high economic value that the prospect of a good marketing in regional, national and international (Suwardji et al., 20 12). However suboptimal land use is still experiencing various obstacles. The constraints in cultivation on suboptimal land are the low quality of soil fertility, mainly characterized by low nutrient availability, poor soil organic matter content and limited water availability for plants (Suzuki and Noble, 2007). It is this factor that is often pointed out as the biggest contributor to the phenomenon of crop failure and low productivity of plants on suboptimal land and the declining quality of agricultural soil fertility and the increasingly vulnerable (fragile) of land to the degradation process (Bastida et al., 2010).

Efficient land use with intercropping planting patterns is an alternative to sustainable agriculture. The ability of intercropping patterns can improve soil fertility through nitrogen fixation in the legume (Lithourgidis et al., 2011). The success of intercropping between maize and soybean is largely determined by the availability of nutrients in the soil. The advantage of intercropping cropping patterns can be seen by calculating Land Equivalence Ratio (LER), in general LER is obtained by comparing intercropping cropping patterns with monoculture cropping patterns (Li et al., 2001).

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Efforts to improve plant growth need to be balanced with the availability of nutrients sufficient to increase production. The addition of soil organic matter causes the soil structure to become cool, nutrient retention capacity and water becomes high, soil buffering capacity is high so that the exchange and supply of nutrients become efficient (Perner et al., 2007) and increases microbial activity (Khalvati et al, 2010). Through its role as stabilizing soil aggregates, organic matter can maintain the physical condition of the soil with the help of soil organisms that use it as an energy source. The population of soil organisms will increase with sufficient soil organic matter content. An increase in soil organisms means biochemical reactions in the soil to be good (Hassen et al., 2001). Improved plant growth can also be increased by the use of arbuscular mycorrhizal fungi (AMF). Kabirun (2002) states that the provision of AMF can increase the dry weight of canopy and plant roots in rice plants. According to Farida (2011) the use of arbuscular mycorrhizal fungi (AMF). can increase the weight of maize per hectare by 2, 63% compared without the use of AMF, whereas according to Astiko et al. (2019) administration of 1 ton per ha AMF, 12 tons per ha of cow manure and 60% recommended dosage of inorganic fertilizer in maize-sorghum cropping patterns gives an increase in the growth and production of sorghum plants in the second cycle.

II. MATERIALS AND METHODS

A. Design of the Experiment

This research was conducted from April to July 2019 in Balai Dana Of The Pemenang Barat Village, Sub-District Of Pemenang, North Lombok Regency. The experimental design used was Randomized Block Design (RBD) with the treatment of 5 intercropping patterns, namely: P_1 = 2 rows of maize : 2 rows of soybean , P_2 = 3 rows of maize : 2 rows of soybean , P_3 = 3 rows of maize : 3 rows of soybean , P_4 = 4 rows of maize : 2 rows of soybean , P_5 = 4 rows of maize : 3 rows of soybean . Each treatment was repeated three times so that 15 experimental plots were obtained.

The seeds used are varieties of hybrid maize seed varieties "BIMA-20-URI " and soybean seeds used are varieties "Anjasmoro". The land is processed using a tractor until it is loose. Then a day later a 5 m x 4.5 m trial plot was made Between plots, 50 cm wide irrigation canals are made with beds as tall as 20-25 cm. Mycorrhizal inoculation is done at planting. Mycorrhizal inoculation isolate $M_{AA}01$ was placed at a depth of ± 10 cm evenly to form a layer. The inoculum used was a mixture of root pieces, fungal spores, fungal hyphae and a culture pot medium that had been in the form of flour as much as 20 g/planting hole. Planting maize and soybean seeds are done by debug. Each hole is filled with 2 maize seeds and 2 soybean seeds with a spacing of maize which is 60 cm x 40 cm, soybean 30 cm x 20 cm. Replanting is done by replanting maize and soybean seeds at the age of 7 DAS. After the plants grow, thinning is done by leaving one plant at the age of 14 DAS.

Fertilization is carried out using a fertilizer organic and inorganic fertilizers to provide a dose of 15 ton/ha (equivalent to 360 g/hole) for maize and (equivalent 180 g/hole) for soybean. Inorganic fertilizer is given as much as 180 kg / ha urea (equivalent to 4.32 g/hole) and 120 kg/ha phonska (equivalent to 2.88 g/hole) for maize plants, while for soybean plants 60 kg/ha Urea (equivalent 0.72 g/hole) and 120 kg / ha phonska (equivalent to 1.44 g/hole) . Fertilizer is given using a cup-shaped measuring container and placed in a planting hole by the dose of fertilizer given. The first fertilization of maize is carried out at 7 days with a dose of 60 kg/ha urea and 60 kg/ha phonska. The second urea and phonska fertilizer were given at 21 DAS the dose of 60 kg/ha, and the third fertilizer was given urea 60 kg/ha at 28 DAS the application. The first soybean fertilization is done by giving 40 kg/ha urea and 20 kg/ha phonska. at the age of 7 DAS and the remaining doses of 20 kg/ha urea and 100 kg/ha phonska given at age 28 DAS

Plant maintenance includes weeding at intervals of 10 days to 50-day-old plants by pulling weeds. Watering plants is sourced from rainfall that occurred in the experimental field. Protection of plants is done with plant-based pesticides from azadirachtin leaf extract with the trade name Organem with a concentration of 5 ml/liter of water by spraying once every 3 weeks.

B. Measurement and Data Analysis

Observations were made on research variables which included number leaves, plant height at 14, 40, 66 and 92 DAS Observations were made on research variables which included number leaves, plant height at 14, 40, 66 and 92 DAS, weight of root biomass and pods plants at 40 DAS and 92 DAS, crop weights, weight of maize cobs and soybean pods per plot and weight of maize cobs and soybean per plant at 92 DAS.

Data were analyzed using an analysis of two ways ANOVA and Tukey's HSD (Honestly Significant Difference) means-tested at a 5% level of significance.

III. RESULTS AND DISCUSSION

A. High plant performance and number of leaves

Table 1 shows the plant height performance and the number of leaves of maize and soybean aged 14, 40, 66 and 92 DAS on intercropping 3 rows of maize: 3 rows of soybean (P3) which were the highest and significantly different from other intercropping treatments (Table 1). The highest spike in plant height and number of leaves was mainly seen in the vegetative maximum age of the plant (66 DAS). In the intercropping composition of 3 rows of maize : 3 rows of soybean.

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The intercropping treatment of 3 rows of maize : 3 rows of soybean (P3) from the age of 66 DAS maize plant height reached an average of twice the height of soybean plants up to the age of 92 DAS. Maize plants that are higher than soybean with a narrow and elongated leaf shape and not branching provide enough space for soybean that grow underneath to grow sideways, as indicated by the number of leaves that are significantly different from the number of leaves of other intercropping treatments. This difference is thought to be caused by the architectural firm of the plant canopy that affects the use of light, water and nutrients by plants and the environment around the plant (Fageria, 1992; Shivaramu and Shivashankar, 1994). Clegg et al. (1974) also stated that the structure of the upper canopy influences the penetration of light into the canopy. To reduce the influence of shade on intercropping, the regulation of planting density between intercropped plants is very important. A high level of shade will reduce the rate of photosynthesis and will increase plant vulnerability (Beets, 1982; Pilbeam et al., 1994).

Intercropping pattern	Plant height (cm) and number leaves							
	14 DAS		40 DAS		66 DAS		92 DAS	
	maize	soybean	maize	soybean	maize	soybean	maize	soybean
Plant height								
P1(2m : 2s)	17.89 [b]	13.44b	59.00 cd	38.89b	165.89ab	61.67bc	164.22bc	49.88c
P2(3m : 2s)	16.78b [c]	14.11b	64.22a	38.88b	166.33ab	66.67ab	161.94c	66.00 b
P3(3m : 3s)	20.77 [a]	17.79a	62.00 ab	58.11a	173.33a	76.22a	176.22a	78.22a
P4(4m : 2s)	17.22bc	13.89b	56.66d	40.00 b	165.00 ab	47.99s	171.44ab	68.88b
P5(4m : 3s)	16.5 0 c	12.77b	53.77e	36.00 c	165.88ab	66.78ab	157.16bc	67.50b
HSD 5%	0.15	0.45	0.75	0.71	82.96	14.67	8.21	3.79
Number leaves								
P1(2m : 2s)	4.54c	4.77s	9.11cd	19.89s	11.66s	45.67bc	11.67a	35.33c
P2(3m : 2s)	4.33c	5.89bc	8.33s	21.33cd	12.22d	53ab	12.33a	39.33bc
P3(3m : 3s)	6.11a	7.89a	12.66a	26.33a	15.55a	56.22a	13.00 a	46.33a
P4(4m : 2s)	5.11b	5.33cd	9.33c	23.77b	13.77bc	46.11bc	11.67a	43.33ab
P5(4m : 3s)	4.22c	3.78e	10.33b	23.55b	14.89ab	50.67abc	11.67a	39.00 bc
HSD 5%	0.02	0.08	0.08	0.31	0.26	6.89	0.38	5.25

Table 1:- Mean plant height (cm) and number of leaves of maize and soybean for each treatment of intercropping pattern (Description: numbers followed by the same letters in the same column are not significantly different)

Plant density is one of the factors that influence the height and number of plant leaves but does not affect competition in maize plants. The growth of maize on intercropping will suppress the growth of soybean especially when soybean is 40 DAS. When maize and soybean are planted together there is a positive interaction, the dominant maize as a C4 plant is generally able to compete with legume crops at the beginning of growth (Maingi et al. 2001). Some studies suggest that maize plants do not have a significant effect on intercropping with soybean (Prasad and Brook, 2005), the taproot system can be intercropped with fiber roots so that it does not harm one plant to another (Dachlan, 2002).

B. Performance weight of plant biomass

Table 2 shows the weight performance of root biomass and shoots at the age of 40 DAS and 92 DAS in intercropping treatment of 3 rows of maize : 3 rows of soybean (P3) which gave the highest value and were significantly different from other intercropping treatments.

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Intercropping pattern	Maize				Soybean			
	Root		Shoots		Root		Shoots	
	40 DAS	92 DAS	40 DAS	92 DAS	40 DAS	92 DAS	40 DAS	92 DAS
Wet Biomass Weight								
P1 (2m : 2s)	35.17c	136.10b	273.3 0c	249.26c	0.66bc	0.79b	11.47ab	15.25cd
P2 (3m : 2s)	30.56d	63.23c	220.00d	166.32d	0.96ab	1.55b	10.70b	11.90de
P3 (3 m : 3 s)	49.22a	191.88a	310.69a	624.63a	1.49a	3.40a	1 8.62a	36.24a
P4 (4 m: 2 s)	47.94a	89.73c	292.00b	369.83b	1.21ab	1.09b	14.51ab	20.44b
P5 (4 m : 3 s)	40.17b	35.8 0d	283.58bc	148.62d	1.30ab	1.34b	15.00ab	19.22c
HSD 5%	1.79	12,39	7.46	29.25	.22	0.65	3.63	3.32
Dry Biomass Weight								
P1 (2m : 2s)	16.60a	46.67b	31.64c	117.41c	0.38ab	0.59ab	2.19b	6.60bc
P2 (3m : 2s)	11.82b	41.82b	47.46b	136.71c	0.31ab	0.94ab	3.21ab	4.59bc
P3 (3 m : 3 s)	17.45a	56.26a	88.93a	381.19a	0.54a	1.81a	3.88a	12.26a
P4 (4 m: 2 s)	15.50a	26.06b	56.76b	250.07b	0.39ab	1.16ab	3.62ab	7.20bc
P5 (4 m : 3 s)	12.35b	12.50c	47.68b	68.97c	0.37ab	0.75ab	1.73c	8.82ab
HSD 5%	1.66	5.29	7,18	14.47	0.11	0.69	0.38	2.49

Table 2:- The Mean Weight of Root Biomass and Shoots at Age 40 and 92 DAS in Different Treatment of Intercropping Patterns (g/plant) (Description: numbers followed by the same letters in the same column are not significantly different)

If the number of rows of maize than 3 lines in added into 4 rows is the number of lines of soybean remain three rows , the result of the weight of root biomass wet and dry maize dropped 5-fold and 4-fold, while the weight of biomass wet and dry shoots down into 4 times and 5 times that .

Crop density on intercropping is related to competition between plants. One factor that is thought to influence is sunlight. Sunlight is used by plants for photosynthesis. The closer the planting distance, the sunlight received by plants decreases, so the photosynthesis process is inhibited and cannot be maximized. As a result, the amount of photosynthate supply decreases and causes the growth and yield of plants to fall, such as the weight of root and shoot biomass per plant. Marliah et al. (2012) showed that the number of pods/plants of the Anjasmoro and Red Fan varieties increased markedly with changes in spacing from 20 cm × 30 cm to 20 cm × 40 cm and 40 cm × 40 cm.

C. Crop performance performance

Table 3 shows the crop weights per plot, a plot of maize cobs and soybean pods and weight of maize cobs and soybean pods being the highest in intercropping patterns of 3 rows of maize : 3 rows of soybean and significantly different from other treatments.

Intercropping pattern	Maize			Soybean		
	WSS (kg/plot)	WSS (g/plant)	WCT (kg/plot)	WSS (kg/plot)	PlPW (g/plant)	PrPw (kg/plot)
Wet Weight						
P1 (2m : 2s)	20.67c	195.49c	31.68b	2.66c	33.43 d	3.79ab
P2 (3m : 2s)	19.10d	163.83d	22.23e	3.90b	30.57 e	4.54ab
P3 (3m : 3s)	26.78a	295.38a	34.57a	5.92a	47.83 a	9.31a
P4 (4m : 2s)	22.70b	227.09b	28.28c	1.20e	42.78 b	4.56ab
P5 (4m : 3s)	25.95ab	143.04d	25.41d	1.95d	37.26 c	2.30ab
HSD 5%	1.10	7.17	1.82	0.13	0.79	7.11
Dry Weights						
P1 (2m : 2s)	15.33b	144,30c	14.70cd	0.53bc	5.40b	0.90b
P2 (3m : 2s)	14.33c	146.57c	12.15cd	0.83b	3.52c	1.68ab
P3 (3m : 3s)	20.94a	278.93a	18.31a	1.21a	11.83a	3.78a
P4 (4m : 2s)	18.13ab	227.09b	15.84ab	0.30cd	10.21ab	1.30b
P5 (4m : 3s)	7.30a	87.25c	14.28 bc	0.39cd	10.30ab	0.82b
HSD 5%	1.55	25.28	1.89	0.29	1.31	3.55

Table 3:- The mean Weight of Stover Crops per plot (kg/plot), Weight of maize cobs and soybean pods Harvest Plots (kg/plot) and Weight of maize cobs and soybean pods Planting (g/plant) at 92 DAS (Description: numbers followed by the same letters in the same column are not significantly different); WSS (Weight Stover Strapping); PCW (Planted Cob Weight); WCT (Weight of Cob Tolls); PlPW (Plant Pod Weight); PrPW (Peripheral Pod Weight)

The arrangement of soybean plants needs to be regulated in such a way if it is intercropped with maize to provide sufficient growth space for both plants so that soybean can be cultivated together with maize. The growth of maize plants is not affected by soybean planting density so that the yield and maize cobs are also not affected. The use of superior varieties of maize on planting density applied to the treatment of 3 rows of maize : 3 rows of soybean with higher and thicker habitus compared to local maize requires appropriate spatial arrangements so that soybean are not too shaded or depressed under maize plants.

To increase the productivity of maize in intercropping systems with soybean is not always done by increasing the population of soybean plants per hectare but can also be done by regulating soybean and maize plants which can reduce the level of competition between the two intercropped crops. Plant density on intercropped 3 rows of maize : 3 rows of soybean that were tried influenced the yield of the weight of the mooring, the weight of soybean pods and pods per plot as well as the highest weight of maize cobs and soybean pods.

The appropriate planting density for maize-soybean intercrops is 3 rows of maize: 3 rows of soybean. At the density of the plant, maize population is 14,700 plants/ha (35% of monoculture) and soybean is 26,135 plants (15% of monoculture). If the number of rows of maize than 3 lines in added into 4 rows moderate amounts of soybean fixed line 3 line, the result of the weight of wet and dry pods per plot of soybean will fall to 4 times as much. This shows that competition occurs when maize overshadows soybean. Muoneke et al. (2007) states that the denser population produces higher production in maize, whereas soybean show lower pod yields. This result is due to intraspecific competition and the effects of maize depression as the dominant C4 plant when intercropped with soybean (Hiebsch, 1995). The decrease in intercropping soybean production is due to the higher shade from maize. Shade by higher plants in intercropping decreases the rate of photosynthesis in the growth of plants below the leaf area, the lower the leaf area because not all leaves are equally efficient in absorbing solar radiation (Olufujo, 1997). Maize production per plot shows the highest yield in the composition of soybean maize intercrops 3 : 3, due to the high maize population and yield per plant.

IV. CONCLUSIONS

The highest spike in plant height and number of leaves was mainly seen in the vegetative maximum age of the plant (66 DAS). In the intercropping composition of 3 rows of maize: 3 rows of soybean. Intercropping of 3 rows of maize: 3 rows of soybean (P3) aged 66 DAS maize height reached an average of twice the height of soybean plants. If the number of rows of maize than 3 lines in added into 4 rows is the number of lines of soybean remain three rows, the result of the weight of root biomass wet and dry maize dropped 5-fold and 4-fold, while the weight of biomass wet and dry shoots down into 4 times and 5 times that. The appropriate planting density for maize-soybean intercropping in the suboptimal soil of North Lombok is 3 rows of maize : 3 rows of soybean. If the number of rows of maize than 3 lines in added into 4 rows moderate amounts of soybean fixed line 3 line, the result of the weight of wet and dry pods per plot of soybean will fall to 4 times as much.

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