Yield Test of Shade-Tolerant Maize Using the Intercropping Method of Maize-Soybean Under Coconut Trees

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Abstract

Maize is a light-dependent crop, but new varieties have been developed that can tolerate shade. This allows farmers to grow maize as an intercrop between coconut trees, making more efficient use of their land. Farmers can also intercrop with legume plants, which provide additional nitrogen through Rhizobium bacteria, leading to increased maize productivity. The aim of this study was to obtain the best intercropping pattern for maize and soybeans under coconut trees that results high yields in maize. The study was conducted in Padang Pariaman Regency of West Sumatra, at an altitude of approximately 150 meters, from February to July 2022. The experimental design was a Split Plot Design with Randomized Block Design, consisting of three main plot levels (planting time) and four subplot levels (planting model). The results of the study indicate that intercropping maize and soybeans under coconut trees has no effect on the weight of maize cobs, but there is a positive correlation between ear weight, cob length, cob diameter, number of rows per cob, and the weight of 1000 maize seeds.

***Keywords**: Intercropping, Maize, Soybeans, Maize Cobs.*

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A. INTRODUCTION

Maize is a food crop whose demand continues to increase every year but is not balanced by its availability. In addition to food consumption, maize is also used as the main raw material for the animal feed industry with a composition of 40-50 percent, of which for independent breeders alone the need is around 3 million tons per year, the food and beverage industry around 1.5-2 million tons per year, and the bioethanol industry around 535 thousand tons per year. Dry shelled maize production in 2023 was 14.46 million tons, which decreased by 2.07 million tons or 12.5% compared to 2022 and in January 2022 alone maize imports were recorded at 32.57 thousand tons or an increase of 0.56% compared to 2020, that is the reason there is to increase maize production by inter-cropping method (BPS, 2022).

Increasing agricultural production of food crops can be achieved through extensification and intensification methods. However, extensification is challenging due to limited agricultural land and high rates of land conversion to housing and plantations. Nevertheless, there is still a considerable amount of land between plantation crops that can be used for other crops, such as the land under coconut trees. Coconuts only use 25% of the land for cultivation (Darwis, 1988), so that 75% of

the land available for other crops, including food crops. One way to increase food crop production is through intercropping systems Yuwariah, 2017), which involves planting two or more crops at the same time (Ahmad et al., 2013; Arief et al., 2012) for instance, maize can be intercropped with legume plants.

Land use under coconuts is one way of optimizing land that will be of higher value and intercropping can increase its value. Although one crop in an intercropping system may produce lower yields, the total production will increase Salli, 2008). The decrease in yield in the intercropping system of corn and soybeans is caused by competition in nutrients, water and light, so that planting density regulation is considered as an alternative to overcome the competition (Pratiwi, 2012; Maharani, 2018).

However, intercropping maize and soybeans under coconut trees can pose several obstacles, including a lack of light intensity. There are some corn plants that are allegedly tolerant of light resistance, such as the NK Sumo variety, which showed the best results with light resistance of 50% (Dewi et al., 2022). Dena 1 soybeans are also allegedly shade resistant up to 50% (Balitkabi, 2016). Apart from light barriers, competition for water, nutrients, and growing space also needs to be considered in maize intercropping.

Intercropping is a form of production diversification that can streamline and optimize land use (Prawata, 2018) and planting corn as an intercrop (Ruskani, 2003) among coconut plants which should only aim to optimize land (Mahdiannoor & Istiqomah, 2015) is expected to be able to become a concern in increasing corn production. This study aims to examine the yield of maize intercropped with soybeans among coconut trees using various soybean planting models. Therefore, a shade-tolerant maize yield test was conducted on intercropping maize and soybeans under coconut trees.

B. METHODS

The experiment was conducted in a coconut plantation owned by the people of Nagari Limau Purut, V Koto Timur District, Padang Pariaman Regency, West Sumatra. The plantation was located at an altitude of approximately 150 meters above sea level and the experiment was carried out from February to July 2022. The materials used for the experiment were shade-tolerant maize varieties (Dewi et al. 2022), specifically NK Sumo, and soybean variety Dena 1. The materials were treated with manure, Urea, pearl NPK, and herbicide with the active ingredient isopropyl amine glyphosate. The tools used included meters, Luxmeter AS803, digital cameras, digital scales, stationery, calipers, net, bamboo, documentation tools, sprayer, hoe, machete, chisel, and other necessary tools.

The maize and soybean intercropping experiment was conducted under coconut stands that were over 35 years old and had a plantation distance of 7M x 7M. The maize variety used was the NK Sumo variety, which can survive 50% shade, and for soybeans, the shade-tolerant soybean variety Dena 1 was used, as recommended by Mutmaidah (2017), and Balitkabi (2016).

The experimental design was a Split Plot Experiment (Split plot design) in a Randomized Block Design. It consisted of 3 levels of main plots and 4 levels of subplots with 3 groups, resulting in 36 experimental units. For each experimental unit, 6 samples of maize and 6 samples of soybeans were taken. The placement of treatments and groups was done randomly.

The Main Plot is the model planting time is:

T1 = Maize planted 20 days after soybeans,

T2 = Maize planted 10 days after soybeans and

T3 = Maize and soybeans are planted together

Subplots are 4 models planting between the double rows of maize (120 cm) with a spacing of maize (60 cm x 20 cm) x 120 cm and between the double rows of maize (120 cm) soybeans are planted with the following treatment:

P1 = 2 rows of soybeans, 1 seed per planting hole

P2 = 2 rows of soybeans, 2 seeds per planting hole

P3 = 3 rows of soybeans, 1 seed per planting hole

P4 = 3 rows of soybeans, 2 seeds per planting hole, with row spacing in soybeans of 20 cm.

To see the effect of treatment on the observed variables, a statistical test is carried out with the F test, if the calculated F of the treatment is greater than the F table, followed by Duncan's New Multiple Range Test (DNMRT) at a real level of 5% (Gomez & Gomez, 1995), To find out the relationship between parameters, correlation and regression analysis is carried out. Data analysis using the Excel program and STAR software.

C. RESULTS AND DISCUSSION

1. Cob Length

Observation variables of cob length, number of rows, and cob diameter are several yield components that will determine optimal maize yield. The difference in the model of intercropping soybeans with maize under coconut plants does not influence the length of maize cobs, but there is a single influence on maize planting time. The length of the cobs is presented in Table 1. It can be seen that when planting maize 10 days after soybeans, it gives the longest cob length which is not significantly different from planting maize at the same time as soybeans and is significantly different from maize plants planted 20 days after soybeans.

Table 1. Cob Length Maize Intercropped with Soybeans Under Stands of Coconut

Planting Time	Planting Model				Single influence of planting time
	2 rows 1 plant 2:1	2 rows 2 plants 2:2	3 rows 1 plant 3:1	3 rows 2 plants 3:2	
	...cm...				
Maize 20 days after soybeans	15.33	15.14	15.69	15.64	15.45 B
Maize 10 days after soybeans	16.59	16.10	15.62	15.83	16.04 A
Maize along with soybeans	17.01	15.54	15.77	14.70	15.76 AB

Numbers followed by the same capital letters in the same column indicate that they are not significantly different based on the DNMRT test at the 5% significance level.

Apart from being influenced by genetic factors, the length of maize cobs is also influenced by environmental factors. Jumin (2005) states that apart from external factors (environment), plant growth is also influenced by factors within the plant it self. If the average ear length of a variety is longer than other varieties, that variety has the opportunity to have higher yields than other varieties (Fitriyani et al., 2019), this is a factor that exists in the plant. From Table 1, it can be seen that planting soybeans 20 days after maize provides shorter cob lengths compared to other planting times.

The maize monoculture treatment under coconut plants produced an average cob length of 16.24 cm, which means it is not too different from the cob length of maize intercropping with soybeans under coconut plants. According to Kartinaty et al. (2019), if the plant's nutritional needs are not met, it will affect the photosynthetic produced. This will also influence cob growth in the form of optimal cob length and cob diameter.

2. Cob Diameter

The results of the analysis of variance showed that there was no interaction between planting time and the intercropping model for maize and soybeans among coconut plants, but there was a single effect of planting model on maize cob diameter. The cob diameter values are presented in Table 2.

Table 2. Cob Diameter Maize Intercropped with Soybeans Under Stands of Coconut

Planting Time	Planting Model			
	2 rows 1 plant 2:1	2 rows 2 plants 2:2	3 rows 1 plant 3:1	3 rows 2 plants 3:2
	...mmm...			
Maize 20 days after soybeans	48.55	48.28	49.09	49.17
Maize 10 days after soybeans	50.25	48.60	48.57	48.67
Maize along with soybeans	50.31	48.20	48.61	48.77

Numbers followed by the same lower-case letter in the row indicate not significantly different based on the DNMRT Test (α =5%).

The largest cob diameter in the 2:1 planting model, namely 49.70 mm, is not significantly different from the 3:2 planting model and is significantly different from other models and the lowest is in the 2:2 planting model, namely 48.67 mm. Meanwhile, in maize monoculture planting under coconut stands, the maize cob diameter was found to be 48.86 mm. The 2:1 planting model with fairly wide spacing for soybeans and a soybean density that is not too high produces larger cob diameters compared to other planting models, namely 2:2, 3:1 and 3:2, which is thought to be due to the lack of planting density and soybean population. also reduces competition with maize plants. Ear diameter is a quantitative character in plants which is generally influenced by many genes influenced by the environment (Syukur et al., 2012).

After conducting a correlation test, cob diameter correlated very strongly with cob length, namely 0.87, which means that the longer the cob, the greater the diameter of the maize cob in intercropping maize and soybeans under coconut stands with several soybean planting models between maize.

3. Number of rows of seeds per cob

The results of the analysis of variance showed that differences in planting time and intercropping models for maize and soybeans under coconut stands had no effect on the number of rows of seeds per maize cob. The number of rows of seeds per maize cob is presented in Table 3.

Table 3. Number of Rows of Cobs Maize Intercropped with Soybeans Under Stands of Coconut

Planting Time	Planting Model			
	2 rows 1 plant 2:1	2 rows 2 plants 2:2	3 rows 1 plant 3:1	3 rows 2 plants 3:2
Maize 20 days after soybeans	13.20	12.77	13.24	12.47
Maize 10 days after soybeans	13.57	13.02	12.73	12.80
Maize along with soybeans	12.89	12.89	12.40	12.47

The numbers in rows and columns are not different according to the F test at the 5% significance level

The highest number of rows of seeds is found in the 2:1 planting model and maize planting time is 10 days after soybeans, namely 13.57 rows, while the lowest number of rows is in the 3:1 planting model and maize together with soybeans, namely 12.40 rows and monoculture maize 12.87 rows. This is thought to be because the number of rows is greatly influenced by plant varieties, namely plant genetic factors, but it is also influenced by external factors such as the availability of nutrients and the environment such as humidity, temperature and sunlight (Jumin, 2005). A high dry shell weight per plot indicates optimal seed filling. High cob weight is caused by the number of seeds in each cob (Ukonze, 2016). Each gene has its own job to grow and regulate various types of characters in the body (Kuruseng & Kuruseng, 2008).

4. Weight of 1000 seeds

The results of analysis of variance showed that differences in planting time and intercropping of soybeans with maize under coconut plants had no effect on the weight of 1000 maize seeds. The weight of 1000 maize kernels is presented in Table 4.

Table 4. Weight of 1000 Seeds Maize Intercropped with Soybeans Under Stands of Coconut

Planting Time	Planting Model			
	2 rows 1 plant 2:1	2 rows 2 plants 2:2	3 rows 1 plant 3:1	3 rows 2 plants 3:2
	...g...			
Maize 20 days after soybeans	318.15	329.07	315.92	313.68

Maize 10 days after soybeans	337.62	334.24	309.91	334.40
Maize along with soybeans	325.78	316.37	333.36	336.82

The numbers in rows and columns are not different according to the F test at the 5% significance level

From Table 4 it can be seen that the weight of 1000 maize seeds in this experiment ranged from 309.91 g to 337.62 g. The weight of 1000 seeds indicates the size of the endosperm in the seeds. According to Berger (1962) the weight of 1000 seeds is influenced by seed size, seed shape and seed content. Seed size is largely determined by genetic factors. Therefore, it is suspected that reduced photosynthesis results due to limited N tend to affect seed shape and seed content, thereby reducing the weight of 1000 seeds.

The weight of the maize kernels almost matches the description of the maize and shows good numbers. This is thought to be because intercropping maize and soybeans provides good results for maize crop yields so that there is no competition for available environmental factors so that the plants can produce optimal seeds. Based on the correlation test, there is also a positive correlation between the number of rows and the weight of 100 maize kernels, but it is very weak.

5. Cob Weight

The results of analysis of variance showed that differences in planting time and intercropping models for maize and soybeans under coconut plants had no effect on maize cob weight. Cob weight is presented in Table 5.

From Table 5 it can be seen that the cob weight ranges from 199.62 g to 238.78 g, namely the lowest value when planting maize 20 days after soybeans with a 2:1 planting model and the highest when planting maize at the same time as soybeans but with the same planting model, namely 2:1. Maize productivity depends on the variety and growing environment. Planting soybeans between maize plants intercropped under coconut plants apparently does not affect the maize yield component in the form of cob weight. In maize monoculture planting under coconut stands, the average cob weight was 218.81 g, which was still between the average maize cobs in maize and soybean intercropping under coconut plants.

Table 5. Cob Weight Maize Intercropped with Soybeans Under Stands of Coconut

Planting Time	Planting Model			
	2 rows 1 plant 2:1	2 rows 2 plants 2:2	3 rows 1 plant 3:1	3 rows 2 plants 3:2
	...g...			
Maize 20 days after soybeans	199.89	199.62	210.85	200.60
Maize 10 days after soybeans	236.22	222.25	207.72	212.23
Maize along with soybeans	238.78	200.63	205.75	211.18

The numbers in rows and columns are not different according to the F test at the 5% significance level

According to Karima et al. (2013), the intercropping treatment given had no effect on maize yield in the form of weight of fresh cobs with husks and weight of fresh cobs without husks. This is because maize has a higher plant height compared to intercropping plants. Ukonze (2016) stated that the high cob weight results may be caused by the number of seeds in each cob measured, so that the cob weight in

this variable is only influenced by the variety used and soybean planting density does not affect the weight of the maize cob. cob length, cob diameter. Welsh et al., 1991 also said an optimum environment for plant growth is also very supportive in increasing production.

After conducting a correlation test, the results showed that cob weight was very strongly positively correlated with cob length and cob diameter and strongly positively correlated with the number of rows of cob kernels and the weight of 1000 kernels.

D. CONCLUSION

Based on observations made during the shade-tolerant maize yield test, the weight and size of the maize cobs are not affected by the soybean planting model, whether it is intercropped with maize or planted under coconut plants. However, the length of the cobs is determined by the timing of soybean planting. The diameter of the cobs is caused by the number of rows and the soybean planting density in between the maize. But there is a positive correlation between ear weight, cob length, cob diameter, number of rows per cob, and the weight of 1000 maize seeds.

REFERENCES

1. Ahmad, M., Khan, M. J., & Muhammad, D. (2013). Response of maize to different phosphorus levels under calcareous soil conditions. *Sarhad Journal Agriculture*, *29*(1), 43-48.
2. Arif, M., Ali, A., Umair, M., Munsif, F., Ali, K., Inamullah, M. S., & Ayub, G. (2012). Effect of biochar FYM and mineral nitrogen alone and in combination on yield and yield components of maize. *Sarhad Journal Agriculture*, *28*(2), 191-195.
3. Central Bureau of Statistics. (2023). *Harvest Area and Maize Production in Indonesia*. Indonesian Central Statistics Agency.
4. Balitkabi. (2016). *Guidelines for cassava cultivation in Indonesia*. Jakarta: Agricultural Research and Development Agency.
5. Berger, J. (1962). *Maize production and manuring of maize*. Geneva: Center d'Etude de l'Azote.
6. Darwis, S. N. (1988). *Intercrops between coconuts*. Bogor Research and Development Center.
7. Dewi, R. K., Suliansyah, I., Anwar, A., Syarif, A., & Rahmah, M. (2022, October). Effect of shading on plant growth of 4 varieties of hybrid corn. In *IOP Conference Series: Earth and Environmental Science* (Vol. 1097, No. 1, p. 012011). IOP Publishing.
8. Fitriyani, D., Kartahadimaja, J., & Hakim, N. A. (2019). Uji daya hasil pendahuluan lima galur jagung (Zea mays L.) hibrida silang tunggal rakitan Politeknik Negeri Lampung. *Jurnal Penelitian Pertanian Terapan*, *19*(1), 89-94.
9. Gomez, K. A., & Gomez, A. A. (1995). *Statistical Procedures for Agricultural Research*. Jakarta (ID): UI Press
10. Jumin, H. B. (2005). *Basics of agronomy*. Jakarta: RajaGrafindo Persada.

11. Karima, S. S., Nawawi, M., & Herlina, N. (2013). *Pengaruh saat tanam jagung dalam tumpangsari tanaman jagung (Zea mays L.) dan brokoli (Brassica oleracea L. var. botrytis)* (Doctoral dissertation, Brawijaya University).
12. Kartinaty, T., Halono, J. D., & Puspitasari, M. (2019). Karakter agronomis tiga varietas jagung dan dosis pemupukan pada sistem tanam tumpangsari di lahan kering. *Jurnal Ilmiah Hijau Cendekia*, *4*(2), 78-86.
13. Kuruseng, H. and Muh. Askari Kuruseng. 2008. Growth and production of various maize plant varieties at two doses of urea fertilizer. Agrisystems Journal Vol. 4 No.1.
14. Maharani, P. D., Yunus, A., & Harjoko, D. (2018). Jarak tanam berbeda pada uji daya hasil lima varietas jagung hibrida. *Agrotechnology Research Journal*, *2*(2), 52-57.
15. Mutmaidah, S., & Sundari, T. (2017). Efisiensi pemanfaatan lahan untuk memaksimalkan pendapatan dengan pola tumpangsari jagung dan kedelai. In *Prosiding Seminar Hasil Penelitian Tanaman Aneka Kacang dan Umbi* (p. 333).
16. Parwata, I. G. A. (2018). Uji Daya Hasil Beberapa Varietas Kedelai Dalam Tumpangsari Dengan Jagung Pada Empat Tipe Agroekosistem Lahan Kering di Pulau Lombok Nusa Tenggara Barat. *AGROTEKSOS*, *7*(3), 8-20.
17. Pratiwi, Y. H. (2012*). Produktivitas kedelai (Glycine max L.) pada sistem tumpangsari jagung (Zea mays L.) secara deret tambah*.
18. Robi'in. (2009). Technique for Testing the Yield Power of Free Pollen Maize (Composite) at the Prima Tani Location, Probolinggo Regency, East Java. *Agricultural Engineering Bulletin*, *14*(2), 45-49.
19. Salli, M, K. (2008). Results of Intercropping Maize (*Zea mays* L.) and Red Beans (*Phaseolus vulgaris* L.) at Different Maize Planting Distances. *Partners*, *15*(1), 57-62.
20. Ukonze, J. A., Akor, V. O., & Ndubuaku, U. M. (2016). Comparative analysis of three different spacing on the performance and yield of late maize cultivation in Etche local government area of Rivers State, Nigeria. *African journal of agricultural research*, *11*(13), 1187-1193.
21. Welsh, R. (1991). *Basics of Genetics and Plant Breeding*. Jakarta: Erlangga.
22. Yuwariah, Y. (2011). *The role of intercropping and intercropping inset sari based on shade-tolerant padigogo*. Bandung: Giratuna.