# The effect of row proportion of maize and soybean intercropping on growth and yield of component crops in sandy soil North Lombok, Indonesia

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# The effect of row proportion of maize and soybean intercropping on growth and yield of component crops in sandy soil North Lombok, Indonesia

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**Abstract** This study aimed to determine nutrient status, mycorrhiza population, and yields of maize-soybean strip intercropping in sandy soil environments of North Lombok, Indonesia. The experiment designed with Randomized Block Design with three blocks and five treatments, i.e., P1 (2 rows of maize: 2 rows of soybean), P2 (3 rows of maize: 2 rows of soybean), P3 (3 rows of maize : 3 rows of soybean), P4 (4 rows of maize: 2 rows of soybean), P5 (4 rows of maize : 3 rows of soybean). The results show that an increase of one more row from 3 to 4 rows significantly decreases the weight of maize cobs (3.5-folds), pods (2.3-folds), and 1000 seeds (1-folds). One row of maize plant density, which was beginning three rows to 4 rows, causes a decrease in the weight of dry root biomass and shoot of maize and soybean plants. The root weight and dried shoots of maize fell to 3.5 and 4.5 times, and the weight of dried roots of soybeans fell to 1.41 times at the age of 92 days after observing the 4:3 ratio of maize and soybean plants.

## 1. Introduction

Generally, maize grows together with soybeans in the intercropping system in the sandy soils of North Lombok. Intercropping is defined as planting two or more plants at the same time and place [1]. The intercropping system is more beneficial compared to the monoculture system due to its high productivity. Besides, various commodities are produced, efficient in production cost, and less risk of crop failure. The intercropping system provides some benefits as preventing erosion and maintaining soil fertility. There is a very complex interaction between two or more pants using water, light, and nutrients [2].

Furthermore, growth factor management is necessary for applying intercropped because the two intercropped plants will complement each other in using resources [3]. Intercropping farming deals with different plant species, so they must consider plant properties such as differences in root systems, plant height, family, and host plants of different pests, population, and planting density [4]. Planting maizes with wide spacing significantly decreases the dry weight of seeds compared to narrow spacing and medium spacing. However, planting with wide spacing has a higher dry weight of seeds per cob; the population is smaller, so the number of cobs is also less [5].

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The intercropping system is included in efforts to diversify agriculture that can be done on maize and soybean plants. This intercropping is possible because maize is included in $C_4$ plants that prefer direct sunlight [6] and require nitrogen in relatively high amounts [7]. Soybeans are included in $C_3$ plants, which are quite tolerant of shade [8]; besides that, soybean roots can fix nitrogen through symbiosis with *Rhizobium japonicum* bacteria [9]. The intercropping system of maize with soybean had a positive influence on maize production [10]. Based on the results can be seen that the intercropping system of soybean and maize is more efficient compared to the intercropping system of soybean and upland rice [11].

The main problem in intercropping is the competition between plants to absorb water, nutrients, sunlight, and growing space. Setting the appropriate proportion of planting density can reduce the shade and optimize production in the maize and soybean intercropping system. Shade can cause changes in the reception of solar radiation by plants, both intensity, and quality so that it affects a variety of plant activities [12, 13].

Therefore, to obtain the best results from maize intercrops with soybeans, it is necessary to adjust the proportion of planting density so that the use of resources is more efficient and does not interfere with the intercropped soybean plants. Adjustments of plant density proportion are to provide better growth space for plant growth and development. Intercropping production is a function of managing aquaculture and the environment, which involves the interaction between soil and microclimate around the plant. Good management of these two factors will result in high crop production [14]. The proportion of planting density suitable for intercropping cotton with soybeans is 1 row of cotton (1 plant/hole) and three soybeans [15]. However, the proportion of density appropriate for intercropping maize with soybeans in the sandy soil of North Lombok has not been revealed. This study was aimed to examine the effect of the proportion of density of maize and soybeans planted with intercropping systems on growth components and crop yields in the sandy soil of North Lombok.

## 2. Materials and methods

The experiment was conducted in Akar-Akar village at the Bayan district of North Lombok from May to August 2020. The land is located at a geographic position of latitude -8.221650 and longitude 116.350283. Randomized Block Design was used in this experiment with five treatments, i.e., P1 (2 rows of maize: 2 rows of soybean), P2 (3 rows of maize: 2 rows of soybean), P3 (3 rows of maize : 3 rows of soybean), P4 (4 rows of maize: 2 rows of soybean), P5 (4 rows of maize : 3 rows of soybean). Each treatment was replicated three times.

Soil tillage was done using a tractor to remove the weeds from the land. The land was then divided into 15 plots of 5 m × 4.5 m size. The soil characteristics, a composite sample of 200 g, were taken (Soil Survey Staff, 2014). An indigenous mycorrhizal fungus, Glomus mosseae (the MAA01 mycorrhizal isolate including the hyphae and the mycorrhizal spores), was used propagation results of culture pots for three months with soil media and manure (1:1) sterile with maize host plants. It was isolated from the dryland area (1,500 spores per 20 g of soils) in Akar-Akar village of North Lombok. AMF inoculation and organic matter from cattle manure (1 ton/ha and 15 tons/ha) for all maize and soybean plots were used as treatments simultaneously and placed under the seeds as much as 20 g per planting holes at a depth of 10 cm. The cattle manure applied was measured with 3.08% total Nitrogen, pH 6.66, 17.70 mg/kg of available P, 2.31 cmol/kg of available K, 10.45 C/N ration, and 32.2% C-organic. Maize or soybean seeds (Bima-Uri 20 variety and Anjasmoro varieties) are planted by planting 2 seeds per planting hole for each treatment of plant density.

At the time of planting, fertilization is carried out with cattle manure (a dose of 15 tons/ha) given to the planting hole (equivalent to 360 g per maize plant and 180 g per soybean plant). Inorganic fertilization for maize plants done 3 times, namely at the age of 7 days after seeding (DAS), age 21 DAS after the plant is 28 DAS after planting. Fertilization of maize given with a dose of 180 kg/ha Urea (equivalent to 4.3 g per plant) and NPK Phonska (15:15:15) at a dose of 120 kg/ha (equivalent to 2.8 g per plant) which is 60% of the recommended dose and for soybean plants is given with 60 kg/ha

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Urea (equivalent 0.79 g per plant) and 120 kg/ha Phonska (equivalent 1.49 g per plant) fertilizer which is the best dose to increase growth, yield and uptake of N and P in the planting patterns of maize - sorghum and soybeans in the dry land of North Lombok. The first fertilization is done at 7 DAS with a dose of 60 kg/ha Urea and 60 kg/ha NPK Phonska fertilizer. The second fertilization with Urea and Phonska fertilizer is given at 21 DAS after a dose of 60 kg/ha. The third fertilizing with Urea fertilizer is given at a dose of 60 kg/ha at 28 DAS. For soybean, Urea and Phonska fertilizers are given at 1/3 dose at the age of 7 DAS, and the remaining 2/3 are given at 28 DAS after planting. NPK fertilizer was applied in a 5 cm groove beside a row of maize and soybean plants at a depth of 5-7 cm before being covered with soil.

Plant protection was done by spraying OrgaNeem (an organic pesticide of plant origin containing Azadirachtin extracted from neem leaves) at a concentration of 5 mL OrgaNeem per Liter of water. Planting is done in the rainy season (April - July) so that the irrigation of the plants is sufficient from the rainfall in the test site. Weeding is done at intervals of 10 days until the plants are 40 das by cleaning the growing weeds. Weeding is done at intervals of 10 days until the plants are 40 das by cleaning the growing weeds. The OrgaNeem solution was applied to both crops (maize or sorghum) from 10 to 60 DAS at a 3-day interval. Harvesting of maize and soybean crops was done at 92 DAS.

Observations were made on research variables: vegetative growth (dry weight of maize roots and soybean) at 40 and 92 DAS, and yields (dry cob and pods yield and weight of 1000 grains of maize and soybean). Plant samples per plot of 5 plants were randomly selected. Data were analyzed using two-way ANOVA and Tukey's HSD (Honestly Significant Difference) means-tested at a 5% level of significance.

## 3. Results and discussion

In terms of dry biomass weight and yield components of maize and soybean, there were significant effects of the intercropping pattern in which three rows of maize and three rows of soybean (P3) treatment presents the highest values of dry biomass weight and yield components (Table 1 and Table 2).

**Table 1**. Mean dry biomass weight (g/plant) of maize and soybean for each treatment of intercropping pattern

| Intercropping pattern | Dry biomass weights (g/plant) of maize and soybean | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Maize root | | Maize shoot | | Soybean root | | Soybean shoot | |
| | 40 DAS | 92 DAS | 40 DAS | 92 DAS | 40 DAS | 92 DAS | 40 DAS | 92 DAS |
| P1 (2m:2s) | $15.28^{bc}$ | $46.67^{b}$ | $36.19^{b}$ | $117.41^{c}$ | $0.40^{b}$ | $0.59^{b}$ | $2.11^{bc}$ | $6.59^{bc}$ |
| P2 (3m:2s) | $11.05^{cd}$ | $41.82^{b}$ | $47.46^{b}$ | $136.71^{c}$ | $0.27^{b}$ | $0.94^{ab}$ | $2.41^{b}$ | $4.59^{c}$ |
| P3 (3m:3s) | $23.27^{a}$ | $56.26^{a}$ | $85.25^{a}$ | $381.19^{a}$ | $0.83^{a}$ | $1.81^{a}$ | $3.81^{a}$ | $12.26^{a}$ |
| P4 (4m:2s) | $17.52^{b}$ | $26.06^{c}$ | $47.58^{b}$ | $250.07^{b}$ | $0.42^{b}$ | $1.16^{ab}$ | $2.55^{b}$ | $7.20^{bc}$ |
| P5 (4m:3s) | $8.45^{d}$ | $12.50^{d}$ | $48.43^{b}$ | $68.97^{d}$ | $0.37^{b}$ | $0.75^{ab}$ | $1.53^{cd}$ | $8.81^{ab}$ |
| HSD 5% | 3.21 | 5.29 | 7.87 | 14.47 | 0.16 | 0.69 | 0.38 | 2.49 |

Mean values in each column followed by the same letters are not significantly different between treatments of intercropping pattern.

In this intercropping research, the plant density affected dry biomass weights, both maize, and soybean. Based on observation, the P3 (3 rows of maize: 3 rows of soybean) resulted significantly among the treatments both 40 and 92 das where every extending row (3 rows to 4 rows) caused a decrease in the weight of root and shoot biomass. In hence, comparing P5 (4 rows of maize: 3 rows of soybean) to P3 (3 rows of maize: 3 rows of soybean) treatment was obtained the maize biomass reduction from 3.5 to 4.5 times, whereas the dried root soybean fell into 1.42 folds for 92 das. The P3 (3 rows of maize: 3 rows of soybean) indicated a higher N soil nutrient due to the transformation of N from soybean to maize. The soybean can release N from by fixation reaction from the air. As expected, soybean plants can release a large amount of N with Rhizobium bacteria in the soil, so stimulated maize growth by introducing soybean intercropping (16). Improvement of soil N nutrients

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due to the N-binding bacteria that can fix N directly from the air in the affected soybean plants also in maize plants, causing the growth of roots and shoot plants to be useful [17]

Table 1, the shoot and root dry weight ratio for P3 (3 rows of maize: 3 rows of soybean) shows results at 3.6 and 6.7 for maize; 4.5 and 6.7 for soybean during 40 and 92 das observation. It indicates the P3 treatment of the plant in a healthy condition and does not stress. This ratio value result describes the overall health of the plant because the ratio is more significant than 1.0. This condition allows the absorption of nutrients by plants prioritized to develop organs on the ground, such as leaves, stems, flowers, and seeds, so that they grow better [18]. The consequence of this incident caused the weight of wet and dry biomass also to be high. This condition forms plants to carry out such a mechanism. This condition not only stimulates nutrient uptake, macro-molecular metabolism, plant growth, and development but also encourages the rate of translocation of assimilation products to landfill organs such as cob and pods [19]. It is known that the shoot root ratio can be caused by location and climatic conditions; according to the results of research, the average shoot root ratio for alfalfa is 1.30. Plants generally store more food reserves in the stems than in roots.

**Table 2.** Mean weight of dry cob and pods yield (g/plant) and 1000 dry grains for each crop and each treatment of intercropping pattern

| Intercropping pattern | Mean dry cob and pods yield (g/plant) and weight of 1000 dry grains (g) | | | |
|---|---|---|---|---|
| | Maize | | Soybean | |
| | Cob yield | 1000 grains | Pods yield | 1000 grains |
| P1 (2m:2s) | 93.11$^{ab}$ | 231.67$^{c}$ | 4.07$^{b}$ | 148.33$^{b}$ |
| P2 (3m:2s) | 83.79$^{ab}$ | 230.00$^{c}$ | 2.87$^{b}$ | 146.66$^{b}$ |
| P3 (3m:3s) | 128.03$^{a}$ | 303.33$^{a}$ | 9.39$^{a}$ | 183.33$^{a}$ |
| P4 (4m:2s) | 108.04$^{a}$ | 236.67$^{c}$ | 3.55$^{b}$ | 160.00$^{ab}$ |
| P5 (4m:3s) | 35.23$^{c}$ | 261.67$^{b}$ | 3.93$^{b}$ | 168.33$^{ab}$ |
| HSD 5% | 30.15 | 13.45 | 1.04 | 18.01 |

Mean values in each column followed by the same letters are not significantly different between treatments of intercropping pattern.

The growth and yield of P3 (3 rows of maize: 3 rows of soybean) improved after introducing mycorrhizal fungi at 1 ton per ha, 15 ton per ha of manure, and 60% inorganic fertilizer of the recommended dosage. The P3 crop density increased the ability and efficiency of plants to absorb phosphorus nutrients to support growth and crop yields because (AMF) hyphal structure enhances the broad nutrient and water exchange area. The Phosphorus is the main element of a high energy substrate (ATP, ADP, AMP) that supports plant metabolism. Also, the substrate encourages reproductive organs and affects increasing by 1000 dry grains also cob, and pods yield. This experiment was appropriated with other research that P fertilization improved seed formation to obtain grain yield [20,21].

The P3 (3 rows of maize: 3 rows of soybean) produced cob weights 128.03 g/plant and pod weights 9.39 g/plant. However, maize rows were increased from 3 to 4 row (P5 treatment), resulting in significant yield loss up to 3.5 times (maize) and 2.3 times (soybean). Furthermore, the 1000 grain weight was reduced from 1.15 to 1.08 times. It proved that P3 is high tolerance in N, P nutrient availability, and absorption, followed by a higher yield of cob, pods, and seeds. This result may be caused by intercropping density and plant spacing. The density affects individual plant growth and yield [22]. Increasing the density of maize plants from 3 rows to 4 rows can reduce the growth of maize and inhibit the growth of soybeans planted with intercropping systems [23,24]. From this research, maize growth aggressivity occurred at a density of four maize rows and three soybean rows that impacted maize and soybean depression because of less photosynthesis in plant leaves.

## 4. Conclusion and suggestions

The results show that crops intercropping density of 3 rows of maize:3 rows of soybean maintain high growth and yield. The increase of one more row from 3 to 4 rows significantly decreases the weight of maize cobs (3.5-folds), pods (2.3-folds), and 1000 seeds (1-folds). The addition of single row density of maize plants, the initial three rows to 4 rows, causes a decrease in the weight of dry root biomass and shoot of maize and soybean plants. The root weight and dried shoots of maize fell to 3.5 and 4.5 times, and the weight of dried roots of soybeans fell to 1.41 times at the age of 92 days after observing the 4:3 ratio of maize and soybean plants.

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