Yield of Soybean and Corn Intercropping Farming in Rainfed Lowland in Central Lampung, Lampung Province

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Abstract. Soybean and corn are strategic commodities to meet community needs. As the population increases, the demand for these commodities tends to increase. A breakthrough innovation is needed to increase food production. The purpose of this study was to determine the yield of several varieties of corn and soybean growth using the intercropping system on rainfed lowland areas. The study was conducted in Central Lampung during the 3rd planting season from September to December 2019. The soybean varieties are Anjasmo, Dena, Devon and local existing. Corn varieties are Nasa-29 and local existing. The intercropping system used corn-soybean pattern 2-7. The study involved 5 farmer cooperators. The results of the study indicated that the intercropping system provide the highest production of soybean and corn for local and existing varieties. The average corn production was 9340 kg/ha and the average soybean production was 1971 kg/ha. The intercropping system provides an increase in the cropping index from 100-150 to 200-300 on rainfed lowland.

1. Introduction

The Law of the Republic of Indonesia number 18/2012 concerning food emphasizes that the implementation of food existence is carried out to meet basic human needs that provide fair, equitable and sustainable benefits based on food security, food independence and food sovereignty [1]. Food security is a condition for the fulfillment of food for the state to individuals, quantity, quality, safe, diverse, nutritious, equitable, affordable, according to religion, belief and culture, to live healthy, active and productive in a sustainable manner. Food self-sufficiency is the ability of the state and the nation to produce various kinds of food from within the country to ensure the fulfillment of food needs at the individual level in a dignified manner. Meanwhile, food sovereignty is the right of the state and the nation to independently determine Food policy. For this reason, the government program on meeting food needs should be a priority in accordance with the mandate of this law.

According to [2], domestic food needs so far have not been able to leave imports. Food imports are mainly to cover insufficient staple foods such as rice, corn, soybean and others. [3] stated that food production, such as rice, corn, and soybean commodities in Indonesia, which tends to be low due to farming methods and narrow land areas. In addition, water is the main limiting factor, without sufficient water the productivity of land and plants is not optimal. Water availability accounts for 16% of the contribution to increased production, 5% of the use of superior seeds, 4% of the application of technology and 75% of the interaction of water, seeds and technology [4]. It shows how important the contribution of water irrigation to increase production [5, 6, 7].
Corn and soybeans are currently an alternative food commodity after the mainstay commodity for rice. The use of corn is mainly used to meet the needs of the animal feed industry. Meanwhile, soybeans are mostly used to meet industrial needs, both home and large industries, such as raw materials for processing tofu, tempeh, soy sauce, vegetable milk and others. In 2019, corn production in Lampung Province reached 2,374,384 ton planted on an area of 426,972 ha, so that the productivity in the area was 5,561 kg/ha. Meanwhile, soybean production in the same year reached 12,318 tons planted on an area of 9,334 ha, so that the average soybean productivity was 1,320 kg/ha. At Central Lampung district level in 2019, corn production reached 325,063 tons planted on an area of 57,547 ha, so that corn productivity in the area was 5,649 kg/ha slightly above the average corn productivity in Lampung Province [8]. Even though the prices of these two commodities have fluctuated, the demand for corn and soybeans remains relatively high. So that the government continues to strive to encourage the production of corn and soybeans in the hope that the need for these two commodities will be met without having to import. Corn and soybean crops can be planted in rainfed lowland after planting rice.

In Lampung, rainfed rice fields are a mainstay for the cultivation of food crops. They are categorized as sub-optimal land due to the reaction of the soil is acidic, less fertile and water availability depends on rainfall. The area of rainfed rice fields in Lampung is estimated to be 121,049 ha [9, 10] or about 27% of the total rice fields of 445,173 ha [11]. The cropping index (CI) of rainfed lowland tends to be low (1 - 1.5). Food productivity, especially rice in rainfed lowlands in the first season is in the range of 3 - 7 ton/ha [12]. Rainfed lowland has the potential to optimize utilization to support increased production and cropping index (CI). Increasing CI is used by cropping patterns [13], cropping rotation [14], and modifying planting schedules [15]. Thus, on rainfed rice fields For the second or third planting season, corn or soybeans can be planted after planting rice in the first planting season.

Several research institutes have produced technological innovations in corn and soybean cultivation, which in essence are to encourage an increase in the cropping index, production and the farmers income. One way to encourage increased production requires intensification of agricultural land and extensification of sub-optimal land [16]. One of the innovations to increase productivity in terms of land intensification is by using intercropping cultivation. According to [17] and [18], types of commodities that can be planted in rainfed and dry land using intercropping technology innovation include rice, corn and soybeans.

There are some research results that can be taken into consideration for planting corn and soybeans. [19] and [20] showed that the productivity of rice and legume intercropping was higher than the monoculture cropping system. Rice and soybean intercropping can be applied because these two plants have complementary effects. Intercropping of cassava with upland rice, corn, soybeans, beans is very potential and prospective [21]. Research by [22] stated that the intercropping treatment of upland rice plants with sweet corn plants tends to have higher yields than intercropping treatment with other plants. Planting corn in paddy fields (4.7 ton/ha) and dry land (4.4 ton/ha) have a little different [23]. Although it requires cash costs to produce corn [24], corn farming in paddy fields remains feasible and profitable [25]. It needs consideration that the farmers’ decision to produce corn is a favorable economic climate [26] and socially acceptable [27]. The purpose of this study was to determine the yield of several varieties of corn and soybean growth using the intercropping system on rainfed lowland areas.

2. Materials and Method
The study was conducted in Central Lampung during the 3rd planting season from September to December 2019. This study implemented an innovative intercropping system technology that could increase corn and soybean production in rainfed rice fields specific to the Central Lampung region. The application of innovative corn and soybean intercropping technology was carried out by modifying the planting system to suit the Central Lampung region from previous research studies such as the study of [16] and [17]. The activity was carried out in a rainfed rice field covering an area of 1.0 ha in Payungrejo Village, Pubian District, Central Lampung Regency, Lampung Province. The study involved 5 cooperative farmers who have rainfed lowland land.
The cropping system model implemented was an intercropping system of corn + soybean with 2 rows of corn and 7 rows of soybean (Turiman Jale 2-7). The tools and supporting materials used in the field are rice seeds, corn seeds, soybean seeds, agricultural production facilities, sign board, wood, bamboo, tape measure, rope, sickle, and so on. The use of new superior varieties (NSV) of corn was in the form of Nasa -29 and local existing (P-36 hybrid). Soybean NSV were Dena-1, Devon, Anjasmoro, and local variety. Corn-soybean row spacing is 30 cm. Corn planting was using 60 cm x 20 cm spacing (in rows), 2 seeds per hole, population around 65-70 thousand/ha. Soybean planting was using 30 cm x 15 cm spacing (in rows), 2-3 seeds per hole, population 300 thousand plants/ha. Soybeans were planted 3 weeks earlier than corn. Biodecomposer was used as much as 2 l/ha (M-Dec, Petrofast, EM-4, etc). Corn seed treatment was using metalaxyl or dimetomorph 200 gr/lit and soybean seed treatment was using Agrisoy 40 gr/8 kg of seeds or Rhizobium 50 gr/liter of water. The use of biological fertilizers was 15-30 kg/ha (Kayabio/Agrimeth/Agriceplus/Petrogani, etc.). The use of organic fertilizer/compost 2 ton/ha. The use of artificial fertilizers: NPK Phonska for corn 450 kg/ha and for soybean 120 kg/ha. The use of urea for corn was 150 kg/ha, and SP-36 for corn is 150 kg/ha, while SP-36 for soybean is 90 kg/ha. And the use of lime/dolomite 1-2 ton/ha during soil cultivation.

The data observed included plant vegetative variables such as plant height, number of leaves, and generative variables related to production components of corn and soybean. Data analysis was performed with analysis of variance (ANOVA) and continued with Duncan test. The data presented using statistical descriptive.

3. Results and Discussion

3.1 Identification of water resources in the Central Lampung Regency

Identification of water resources had been carried out in Central Lampung Regency in January-December 2019. It was carried out by survey methods and desk studies with stages: (1) Seeing the potential of natural resources in prospective survey locations that have not been utilized or their water potential can be improved as irrigation sources, (2) Download the base map from Google Earth using the Map Combiner and QGIS applications, (3) Survey locations at SDA points using the Avenza application, to map location points, elevations, and real time images during surveys on Google Earth, (4) Data taken during the survey were coordinate points, altitude, identification of natural resources (area, length, width, depth, water discharge), potential irrigation area, water building recommendations, identification of rice fields/cropping areas, and farmer group data.

From the identification results, it was obtained that the service area of the potential water resources that can be used as irrigation services are reservoirs (100 ha), trench dams (1050 ha), long storage (700 ha), so that the total area of land that has the potential for served irrigation is an area of 1850 ha. This water resource potential is predicted to be able to increase the cropping index from CI 150 to CI 200 or 300. Water management in the water resource area has not been utilized optimally, because the supporting infrastructure has not built yet. Thus, if infrastructure is built in accordance with the potential of its water source, the potential for increased production that can be achieved from the harvest produced in the 2nd Planting Season (PS-2) and 3rd (PS-3) with commodities according to specific technological innovations that suit farmers' interests.

3.2. Corn yield in the intercropping system

Corn yield in the 2-7 corn and soybean intercropping system in Pubian, Central Lampung are presented in Table 1. Planting was carried out in the 3rd planting season (PS-3), after planting rice in PS-1 and PS-2. The varieties of corn planted were Nasa-29 (innovations from IAARD) and local existing (hybrid P-36) which was widely available in the research area. Meanwhile, the soybeans planted were varieties of Anjasmoro, Dena, Devon and local superiority from Tanggamus. The growth of corn in the corn-soybean turiman planting system showed a pretty good results.

The vegetative growth variable of corn showed that the height of the corn plant in the intercropping of corn P-36 with soybean varieties Dena is the only significant difference in the Duncan test at 5% level. This was possible because Dena is a shade-tolerant variety that did not compete with corn.
Meanwhile, corn intercropped with Anjasmoro, Devon and local Tanggamus soybean varieties did not show any significant differences.

The variable number of corn leaves showed that only for the existing local corn (P-36 hybrid) intercropped with soybean varieties Dena had a significant difference in the Duncan test at 5% level. This condition was possible because Dena is a shade-tolerant variety that did not compete with corn plant in its vegetative growth so that it is in line with the height and number of leaves. Meanwhile, corn intercropped with Anjasmoro, Devon and local Tanggamus soybean varieties did not show any significant differences.

Table 1. Growth and Production Parameters of Corn Plants in the Turiman Jale 2-7 System in Pubian, Central Lampung, 2019.

| No | Intercropping Type | Plant Height (cm) | Leaves number | cob weight (gr) | Plant numbers per tile (6.25 m²) | Cob numbers per tile (6.25 m²) | Shelled seeds weight (kg/ha) | Productivity (kg/ha) |
|----|-------------------|------------------|---------------|---------------|-------------------------------|-------------------------------|----------------------------|------------------------|
| A. Corn (Nasa-29) + Soybean: |
| 1. Anjasmoro | 179,67<sup>b</sup> | 11,37<sup>b</sup> | 149,51<sup>a</sup> | 40,87<sup>b</sup> | 26,87<sup>b</sup> | 2598,25<sup>a</sup> | 9279,47<sup>b</sup> |
| 2. Dena | 156,00<sup>b</sup> | 11,15<sup>b</sup> | 141,24<sup>b</sup> | 33,20<sup>ab</sup> | 22,20<sup>b</sup> | 2537,28<sup>a</sup> | 9061,72<sup>b</sup> |
| 3. Devon | 158,70<sup>b</sup> | 11,20<sup>b</sup> | 130,94<sup>a</sup> | 32,60<sup>ab</sup> | 24,80<sup>ab</sup> | 2855,27<sup>a</sup> | 10197,41<sup>b</sup> |
| 4. Lokal | 162,18<sup>b</sup> | 11,40<sup>b</sup> | 130,35<sup>a</sup> | 34,48<sup>ab</sup> | 27,53<sup>b</sup> | 2742,63<sup>a</sup> | 5877,07<sup>a</sup> |

B. Corn (Pioneer 36) + Soybean:

1. Anjasmoro | 178,10<sup>b</sup> | 11,03<sup>b</sup> | 177,99<sup>a</sup> | 38,07<sup>ab</sup> | 25,53<sup>ab</sup> | 2948,61<sup>a</sup> | 10530,76<sup>b</sup> |
| 2. Dena | 113,60<sup>a</sup> | 10,25<sup>a</sup> | 156,97<sup>a</sup> | 28,00<sup>a</sup> | 22,20<sup>a</sup> | 3054,63<sup>a</sup> | 10909,40<sup>b</sup> |
| 3. Devon | 171,25<sup>b</sup> | 11,20<sup>b</sup> | 153,73<sup>a</sup> | 31,10<sup>ab</sup> | 25,80<sup>b</sup> | 3550,49<sup>a</sup> | 12680,33<sup>c</sup> |
| 4. Lokal | 179,32<sup>b</sup> | 11,22<sup>b</sup> | 155,40<sup>a</sup> | 32,84<sup>ab</sup> | 25,53<sup>ab</sup> | 2887,41<sup>a</sup> | 6187,30<sup>a</sup> |

Source: field observation data, 2019.

Note: The moisture content of the corn harvest is 22%; the numbers followed by the same letter are not significantly different in the Duncan test at 5% level.

In the plant number variable, only the intercropping of P-36 with Dena varieties and Nasa-29 with Anjasmoro varieties showed a significant difference in the Duncan test at 5% level. This indicates that the corn-soybean intercropping has the maximum corn growth with Nasa-29 and Anjasmoro soybeans. Meanwhile, P-36 corn with Dena soybeans had the most stunted growth. The intercropping of corn combined with Devon and Tanggamus local soybean varieties showed no significant difference.

Meanwhile, in the shelled seeds weight variable, both the Nasa-29 variety and the P-36 hybrid, which were intercropped with Dena, Anjasmoro, Devon and local Tanggamus soybean varieties did not show significant differences in the Duncan test at 5% level. However, productivity of Nasa-29 and P-36 hybrids which intercropped with Anjasmoro, Dena, Devon and local soybeans showed significantly different results in the Duncan test at 5% level.

The yield of Nasa-29 corn intercropped with Devon soybeans gave the highest productivity of 10197 kg/ha at 22% moisture content, while with Anjasmoro soybean 9279 kg/ha, with Dena variety 9061 kg/ha, and with local soybean 5877 kg/ha (Table 1). The yield of existing local corn (P-36 hybrid) intercropped with Devon soybeans gave the highest productivity of 12680 kg/ha at 22% moisture content, while with Anjasmoro 10530 kg/ha, with Dena soybean 10909 kg/ha, and with local soybean 6187 kg/ha.

3.3. Soybean yield in the intercropping system

The results of research on the growth and production of several soybean varieties which are planted through the intercropping system with various corn plants are shown in Table 2. Soybean plant height ranged from 37.41 cm to 56.59 cm. The results of the analysis of variance showed a significant
difference only in the combination of intercropping between Devon soybean and P-36 hybrid corn, while Anjasmoro, Dena and local varieties did not show significant differences in the 5% Duncan test. On the variable of the number of branches, the range was 2.21 to 3.40. The results of the analysis showed that the number of branches, number of pods, stover weight, number of plants, seeds weight per tile, and soybean production per hectare had significant differences in the analysis of variance and continued with the Duncan test at 5% level. The lowest number of pods was 32.62, while highest number of pods was 54.13 in the intercropping of Dena soybean with Nasa-29 corn. For the variable of plant stover weight ranged from 8.85 gr to 20.19 gr. The highest stover weight was in the intercropping of Dena soybeans with Nasa-29 corn. In terms of uniformity and growth, it was shown in the variable of plants number that could be harvested in the tile area ranged from 56.67 to 87.80 plants. The highest plant population that can be harvested in the tile area was the intercropping of local soybeans with P-36 hybrid corn. This condition was possible because the local soybean varieties have been adaptive to be planted in the Central Lampung region so that the opportunity to grow well is very high.

The soybean weight yield per tile variable showed a yield range of 288.42 gr to 529.91 gr. The yields showed significant differences in the intercropping combination between soybeans and corn. The highest weight per tile soybean was in local soybeans with P-36 hybrid corn intercropping, while the lowest weight was found in the Devon and Nasa 29 corn intercropping.

### Table 2. Growth and Production Parameters of Soybean Plants in the Turian Jame 2-7 System in Pabian, Central Lampung, 2019.

| No. | Intercropping type | Plant Height (cm) | Branch number | Pod number | Stover weight (gr) | Plant number per tile | Seeds Weight per tile (gr) | Productivity (Kg/ha) |
|-----|--------------------|------------------|---------------|------------|-------------------|-----------------------|--------------------------|---------------------|
| A.  | Corn (Nasa-29) + Soybean: |                  |               |            |                   |                       |                          |                     |
| 1.  | Anjasmoro          | 50.63<sup>b</sup> | 2.21<sup>a</sup> | 40.15<sup>b</sup> | 16.91<sup>c</sup> | 60.11<sup>a</sup> | 419.73<sup>abc</sup> | 1998.73<sup>abc</sup> |
| 2.  | Dena               | 56.59<sup>b</sup> | 3.18<sup>bcd</sup> | 54.13<sup>d</sup> | 20.19<sup>d</sup> | 60.84<sup>a</sup> | 392.82<sup>abc</sup> | 1870.57<sup>abc</sup> |
| 3.  | Devon              | 39.89<sup>a</sup> | 2.52<sup>abc</sup> | 32.62<sup>a</sup> | 12.19<sup>b</sup> | 66.00<sup>b</sup> | 288.42<sup>a</sup> | 1373.40<sup>a</sup>  |
| 4.  | Lokal              | 50.60<sup>b</sup> | 3.40<sup>d</sup>  | 43.05<sup>bc</sup> | 8.95<sup>a</sup>  | 85.93<sup>b</sup> | 451.87<sup>bc</sup> | 2151.78<sup>bc</sup> |
| B.  | Corn (P-36) + Soybean: |                  |               |            |                   |                       |                          |                     |
| 1.  | Anjasmoro          | 50.78<sup>b</sup> | 2.41<sup>ab</sup> | 41.36<sup>b</sup> | 13.90<sup>b</sup> | 74.50<sup>b</sup> | 468.32<sup>c</sup> | 2230.07<sup>c</sup> |
| 2.  | Dena               | 51.22<sup>b</sup> | 3.15<sup>bcd</sup> | 48.39<sup>d</sup> | 17.53<sup>cd</sup> | 56.67<sup>c</sup> | 438.52<sup>bc</sup> | 2088.17<sup>bc</sup> |
| 3.  | Devon              | 37.41<sup>a</sup> | 2.94<sup>bcd</sup> | 37.19<sup>b</sup> | 11.09<sup>b</sup> | 57.34<sup>c</sup> | 322.45<sup>ab</sup> | 1535.48<sup>ab</sup> |
| 4.  | Lokal              | 50.71<sup>b</sup> | 3.25<sup>d</sup>  | 52.56<sup>d</sup> | 11.31<sup>b</sup> | 87.80<sup>d</sup> | 529.91<sup>c</sup> | 2523.37<sup>bc</sup> |

Source: field observation data, 2019.

Note: The moisture content of the soybean harvest is 13%; the numbers followed by the same letter are not significantly different in the Duncan test at 5% level.

Local varieties of soybean which were intercropped with Nasa-29 corn showed a relatively lower production compared to the P-36 variety. The soybean intercropping with Nasa-29 corn showed a significant difference at the 5% Duncan test level. The yield of local varieties of soybeans gave the highest yields compared to Devon, Anjasmoro, and Dena varieties. The productivity of soybean intercropped with the Nasa-29 corn plant gave the highest production of 2151 kg/ha (local varieties), while Dena 1870 kg/ha, Devon 1373 kg/ha, and Anjasmoro 1998 kg/ha.

Meanwhile, the soybean intercropping with P-36 hybrid corn showed a significant difference at the 5% Duncan test level. Local varieties of soybeans also provide the highest production (2523 kg/ha) compared to other soybean varieties Anjasmoro (2230 kg/ha), Dena (2088 kg/ha), and Devon (1535 kg/ha). The results of the intercropping system for corn and soybeans were in line with studies conducted by [28] where the intercropping of hybrid corn and soybeans gave significant corn yield. Meanwhile, in the Research Institute for Various Beans and Tubers, where the intercropping of corn and soybeans gave optimal results for corn grown by double rowing with a population of 100,000
plants/ha, and between the double rows of corn planted 3 rows of soybeans with a population of 375,000 plants/ha, and corn was planted 20 days after planting soybeans [29].

4. Conclusions
1. The average yield of corn and soybean in rainfed lowland in Central Lampung with the corn-soybean intercropping system (Turiman Jale 2-7) was 9340 kg/ha and 1971 kg/ha, respectively.
2. The highest yield of corn was in the intercropping of local existing hybrid corn (P-36) with soybean Devon variety at 12680 kg/ha, and the lowest corn yield was in the intercropping of Nasa-29 corn with local varieties of soybean at 5877 kg/ha.
3. The highest yield of soybean was in the intercropping with local existing hybrid corn (P-36) with the local varieties at 2523 kg/ha, and the lowest yield of soybean was in the intercropping Nasa-29 corn with soybean Devon varieties at 1373 kg/ha.
4. The corn-soybean intercropping system (Turiman Jale 2-7) was very suitable for planting in the third planting season (PS-3) so as to provide an increase in the cropping index in rainfed lowland areas in Central Lampung, from CI 100-150 to IP 200-300.
5. In the future, to increase corn and soybean production and the cropping index in rainfed lowland areas in Central Lampung District, it is necessary to replicate and apply innovative intercropping technology between corn and soybean (Turiman Jale 2-7) in other regions. The key is to calculate and apply a calendar of planting time to anticipate the availability of water in the third planting season (PS-3).

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