Adaptation test of various dry-land composite corn varieties in Sigi regency, Central Sulawesi

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Abstract. The study aims to determine the adaptation of several varieties of composite corn in dry land. The study was carried out in Bulili Village, Nokilalaki Subdistrict, Sigi Regency, Central Sulawesi Province with an area of 6 hectares, conducted in March to June 2019. The research design used was Randomized Design, consisted of four composite corn varieties (Sukmaraga, Lamuru, Srikandi Kuning and Anoman) as a treatment with eight replications. Variability adaptation test is equipped with economic feasibility analysis and farmer perception to composite corn. Data were analyzed using analysis of variance (F Test) and Duncan’s Multiple Range Test (DMRT) at 5% level. Economic feasibility was measured using RC ratio while farmer perception was measured by scoring methods. Materials and tools used include composite corn seeds, Dry Soil Test Equipment, and scales. Adaptation observation parameters include growth and yield components. The results of the study showed that the Lamuru variety gave a significantly different growth and yield compare to Sukmaraga, Srikandi Kuning and Anoman varieties. Appropriate and high-yielding varieties at the study site were Lamuru and Sukmaraga (8 t/ha) and the lowest was Anoman (7 t/ha). All economically feasible which respectfully RC ratios are Lamuru 1.30, Sukmaraga 1.30, Srikandi Kuning 1.22; and Anoman 1.17.

1. Introduction
Corn is one of very strategic food commodities due to its vital role in national as well as regional economy. This food crop commodity is actively developed in Central Sulawesi besides rice and soybean. Corn potentials according to its content substances include 70% starch, 10% protein, and 5% fat [1]. Corn is demanded in a large quantity every year for animal feeds, foods, and industrial raw materials [2-6]. Corn demand as feed is particularly in poultry that accounts 50% of the total national demand [7, 8]. Corn utilization for feed will continue to increase in the future with an estimation of more than 60% of the total national demand. Other corn utilizations consisted of direct food, raw material of non-cholesterol vegetable oil, corn flour, and snacks [5]. In the future, it is not impossible that Indonesia uses corn as an alternative raw material for bio-fuel industries [5, 9].

The high and increasing demand of corn must be counterbalanced with increased production in meeting the domestic market demand. The national corn productivity in 2005 was 3.45 t/ha dry shelled corn and it was 4.21 t/ha dry shelled corn in 2009, or an increase of 4.78%, on average [10]. The increased corn production for the last few years is still unable to meet domestic corn demand; thus,
breakthroughs in ready-made technology innovation are required to increase domestic corn production [11]. Current corn productivity of Central Sulawesi reaches 4.1 quintal/ha [2]. This number is lower than previous research result from Indonesia Cereal Research Institute (ICeRi), Maros on hybrid corn and composite corn varieties using corn PTT-approach technology where its production could reach 7-9 ton per hectare [1, 4].

Rice-field limitation also becomes an obstacle in corn development; hence, current production enhancement is directed to dry land that has low soil fertility level and is not yet utilized for agriculture [1]. Various efforts to augment domestic corn production have been applied. These efforts include the utilization of high-quality new superior variety (VUB) and corn planting area extension by employing unproductive plantation land. Corn farmers in Sigi Regency, Central Sulawesi generally plant corn seeds from previous harvest. It has been going on for a long time; thus its quality or production reduces. Some farmers choose to plant hybrid corn that bears more intensive handling and requirements including fertile land and intensive cultivation technique, such as recommended fertilization. The hybrid corn seed price at the market is relatively high and with the farmers’ low purchasing power it will have impact on productivity decrease. Therefore, composite corn becomes an alternative for farmers as it has an affordable price and suitable for marginal lands including dry land. Despite its lower fertilizer dose input, the composite corn is still able to grow well compared to hybrid corn that uses higher inputs in marginal land. The agricultural research and development agency through ICeRi has produced composite corn varieties, such as Lamuru, Srikandi kuning, Sukmaraga, and Bisma. These varieties have the following superiorities: (1) it can be planted repeatedly compared to hybrid corn based on its source seeds, (2) it is tolerant to drought, (3) it could grow well in marginal lands, (4) it requires lower fertilizer dose input application compared to the hybrid, and (5) it requires less water in an area with lack of water compared to the hybrid corn [12].

Central Sulawesi, especially Sigi Regency has a spacious dry land potential for corn development including unproductive cocoa land. One effort to increase dry land productivity is by using adaptive superior varieties [13]. Due to its superiorities in marginal land the composite corn has a potential to be developed in Sigi Regency, Central Sulawesi. The development needs a support from the availability of several adaptive composite corn varieties. There are several options of composite corn varieties that presumably suitable to be developed in dry land and will be acceptable and adopted by farmers in Central Sulawesi. The research thus aims to find out and test the adaptation of composite corn varieties in wet climate dry land in Sigi Regency and to select adaptive composite corn varieties in Sigi Regency, Central Sulawesi.

2. Material and Methods

2.1 Location and Time
The research carried out in Bulili Village, Nokilalaki Sub-district, Sigi Regency, Central Sulawesi Province during planting season (PS) I from March – June 2019.

2.2 Research Design
The research took place in farmers’ land by testing four composite corn varieties, namely: Sukamaraga, Lamuru, Srikandi Kuning, and Anoman. It used randomized block design (RBD) with non-factorial group that involved four cooperator farmers. Each cooperator farmer planted one variety as a treatment with eight repetitions. Each repetition was 2,500 m2; thus, area planted by each farmer was 2500 are.

A technology package is presented in Table 1. Cultivation stage was started with land clearing by spraying contact herbicides. Seed treatment was carried out prior to planting using Metalaxyl active ingredient to prevent downy mildew disease. Plant spacing used was 75-80 cm x 40 cm (2 seeds per hole). An integrated plant-disturbing organism control carried out by conducting direct field observations and pesticide spraying. Crop cutting test of each hectare area used 10 meter x 10 meter of size. Harvest was done if the crops were in physiological ripeness indicated by the existence of black layer ± 50 percent in corn ear and corn ear is dark brown. Data collected consisted of agronomic data
(crop height, number of leaves, stem diameter, ear length, number of row per ear, 250 seed weight, crop cutting test results, number of input (production facilities, labor) used, and corn yield. Observations were made on 10 crop samples determined with zigzag method in each plot.

Table 1. Technology Package Used on Composite Corn varieties in Sigi Regency, in 2019.

| No. | Technology Component       | Plant Management                                      |
|-----|---------------------------|-------------------------------------------------------|
| 1.  | Land cultivation           | No Tillage                                            |
| 2.  | Variety                   | Lamuru, Sukmaraga, Srikandi Kuning, and Anoman        |
| 3.  | Seed treatment            | Seed treatment used Metalaxyl                          |
| 4.  | Seed requirement           | 20 kg/ha                                               |
| 5.  | Plant spacing             | 75-80 cm X 40 cm (2 seeds per hole)                    |
| 6.  | Fertilization             | According to PUTK (urea 350 kg/ha, NPK 15-15-15 400 kg/ha) |
| 7.  | Weeding and bedding       | Integrated weed control at the age of 15 and 30 days after planting along with bedding |
| 8.  | Pest control              | Integrated pest and disease control                   |
|     | Harvest and post-harvest  | During physiological ripeness and when black layer on corn ear appear |

2.3 Analysis Method

Data were statistically analysis using analysis of variance (F test), if F value is significant, further test will be carry out using Duncan’s Multiple Range Test (DMRT) at a level of 5%. Economic feasibility analyzed using R/C and B/C ratio. Analysis used referred to [14][15] as follows. Revenue-Cost Ratio (R/C) analysis with formula:

\[
R/C = \frac{\text{Total Revenue}}{\text{Total Cost}}
\]

Benefit-cost Ratio (B/C) analysis with formula:

\[
B/C = \frac{\text{Total Income}}{\text{Total Cost}}
\]

Collecting survey was done to members of farmer group involved in the adaptation test activity that consisted of 20 farmers. Data of farmer perception of composite corn were measured using scoring method with Likert Scale [16]. The value range of respondents’ closed response was 1 – 4 from positive statements (expected responses) with a score of 4 up to negative statements (unexpected response) with a score of 1.

The score value calculation used the following formula.

Score value \( \frac{n_is_i}{N_i} \)

\( n_i = \) the number of respondent who stated in column i \( (i = 1, 2, 3, \ldots 5) \)

\( s_i = \) score of statement i \( (i = 1, 2, 3, \ldots 5) \)

\( N_i = \) the number of respondent in row i \( (i = 1, 2, 3, \ldots 5) \)
3. Results and Discussion

3.1 Area Characteristics

Sigi Regency has an area about 5,196.02 km² that consists of 10 sub-districts [17] and the population mostly works as a farmer. Nokilalaki sub-district is one of sub-districts resulted in from regional expansion of the host sub-district, Palolo sub-district. Nokilalaki sub-district has an area of 75.19 km². Most of the areas are food crop (rice, corn) planting area and plantation (cocoa). Sigi Regency has corn area of 52,022 ha with productivity level of 50.03 quintal/ha and plantation (cocoa) area of 19,354 ha [17]. The low cocoa productivity is due to cocoa pod borer attack that causes a decrease in productivity of 0.8 ton per hectare with yield potential of 2.5 ton/ha. Farmers with low cocoa land productivity shift to corn commodity.

Soil analysis using dry soil test equipment (PUTK) resulted in nutrient status of low phosphate (P) level, medium potassium (K) level, low organic carbon, and pH of slightly acidic (Table 2). The PUTK only provides qualitative soil nutrient status. Based on the nutrient status, the inorganic fertilizers required included urea of 350 kg/ha and NPK 15-15-15 of 400 kg/ha. Average rainfall for the last 5 years (2014-2019) was 134 mm – 339 mm/month with number of rainy days of 14 - 23 days. The highest rainfall was in June – July. Table 1 indicates that rainfall during the research (July-October 2019) was low, especially on August to October, which was less than 100 m/month, with number of rainy days of 8-10 days. This conditions will influence crop growth and yield. Stated that corn requires average rainfall of 25 mm/week to grow well. The climate type for Central Sulawesi were E1, E2, E3, and E4 (the land generally extremely dry and only one palawija planting season and it also depends on rain). The rainfall criteria was 5-20 mm/day (light rainfall).

Table 2. Soil nutrient status of research locations and fertilization recommendation in Bulili Village Nokilalaki Sub-district Sigi Regency, Central Sulawesi 2019.

| Nutrient          | Value  | Recommendation                                                                 |
|-------------------|--------|--------------------------------------------------------------------------------|
| Phosfor           | Low    | Use single fertilizer after conversion, the fertilization recommendation: urea 350 kg/ha, NPK 15-15-15 400 kg/ha. |
| Kalium            | Medium |                                                                                |
| Organik Carbon    | Low    |                                                                                |
| Soil pH           | Slightly acidic |                                                                                |

Note: Soil nutrient measurement using PUTK

3.2 Composite Corn Technology Innovation in Dry Land

One of success factors in corn farming activity is the involvement of stakeholders in the region and farmers as agent of changes and as field actor. The field survey results indicated that farmers were generally planted hereditary varieties. Previous harvest yield was used as seed sources. The high price of hybrid corn seeds enforced the farmers to use seeds up to their second generation (F2). The farmers' low purchasing power drove the farmers to use the available seeds [18]. Poor quality seeds utilization could reduce productivity; thus, it requires innovation breakthrough in technology that is easy to apply, less expensive and could increase productivity, which is high quality seeds.

The low purchasing power of farmers to obtain quality seeds had implication on fertilizer utilization that was still below the recommendation. The farmers also lack of capital; thus they used fertilizer of 0 kg – 150 kg/ha. The benefit of fertilizer application in the farmer level was considered low in terms of the fertilizer dose application, fertilization methods, and application time. The farmers generally spread the fertilizer, but the doses had not met the crop nutrient requirement. As regards fertilization method and application time, the farmers usually fertilized the crop by spreading and the application was 15 – 30 days after planting for the first fertilization. Hence, technological assistance is a necessity to increase production and productivity.
3.3 Crop Growth and Yield Components

Growth is a process in crop life that causes some changes in size, weight, stem volume and diameter from time to time. Crop growth components measured in the research consisted of crop height, number of leaves, stem diameter, ear length, ear diameter at harvest, number of rows per ear, number of seeds per ear, and productivity. Data on growth components included crop height, number of leaves, stem diameter, ear length, and ear diameter are presented in Table 3. All the composite corn varieties had good growth (Table 3). It implied that each variety had a good response to water limitation in rainfed dry land and was responsive to NPK Phonska added with Urea fertilizer application.

One of growth responses that reflects variety adaptation is crop height. Sukmaraga variety had the highest crop height of 287.17 cm compared to other varieties as well as its variety description. It followed by Lamuru variety (277.5 cm), Srikandi Kuning (220.50 cm), and the lowest was Anoman (268.17 cm) as presented in Table 3. The observation results supported by the statistical analysis results indicated that crop height of the four tested varieties had a significant influence (P<0.05). Differences in crop height of the four tested varieties were assumed to be related to genetic factors of the varieties as well as environmental factors. Similarly, [19] stated that crop height parameter is extremely sensitive to certain environmental factors, such as light and water. It could be observed from crops that lack of light will be taller than those that receive light. Likewise, crop that lack of water will have shorter growth compared to those that receive water. Therefore, the tested composite corn varieties were able to adapt well according to the crop height growth parameter.

Other growth component parameters, such as number of leaves, stem diameter, ear length, and ear diameter had a significant influence for each variety (treatment). Lamuru variety had the highest number of leaves, stem diameter, ear length, and ear diameter compared to other varieties. The highest number of leaves was found in Lamuru variety (13.33 cm), whereas the lowest was in Anoman and Srikandi of 11.33 leaves each. The highest stem diameter also found in Lamuru variety of 25.45 mm, whilst the lowest was in Anoman variety of 23.26 mm. Ear length parameter had no significant influence for the four varieties. The highest ear diameter obtained by Lamuru variety of 25.45 mm, whereas the lowest was Anoman variety of 12.24 mm.

Table 3. Average composite corn agronomical performance in Bulili Village, Nokilalaki Sub-district, Sigi Regency, 2019

| Treatment    | Crop Height (cm) | Number of Leaves (leaf) | Stem Diameter (mm) | Ear Length (cm) | Ear Diameter (mm) |
|--------------|------------------|-------------------------|--------------------|-----------------|-------------------|
| Sukmaraga    | 287.17a          | 11.67b                  | 23.86c             | 18.41a          | 44.41b            |
| Lamuru       | 277.50b          | 13.33a                  | 25.42a             | 18.72a          | 51.24a            |
| Srikandi Kuning | 220.50d        | 11.33c                  | 24.68b             | 18.54a          | 45.59bc           |
| Anoman       | 268.17c          | 11.33c                  | 23.26c             | 17.46a          | 42.47b            |
| KK (%)       | 5.96             | 4.84                    | 8.77               | 4.67            | 8.16              |

Note: Average value in the same column followed by the same letter indicates insignificant different in the DMRT test at the confidence level of 95%.

The utilization of new superior variety with high yield potential combined with appropriate fertilizers will result in high contribution to production increase [20]. [4] also carried out similar study in composite corn crops of Lamuru using N, P, and K fertilizers with seed yield per ton of 7.86 t/ha. The average yield and yield components of the composite corn crops are displayed in Table 4.
Table 4. Average yield and yield components of composite corn in Bulili Village, Nokilalaki Sub-district, Sigi Regency, 2019

| Treatment      | Number of seeds per row | Number of seeds per ear | 250 seed weight (gram) | Crop cutting test result (t/ha) |
|----------------|--------------------------|-------------------------|------------------------|-------------------------------|
| Sukmaraga      | 17.67b                   | 38.68a                  | 93.36a                 | 7.20a                         |
| Lamuru         | 18a                      | 38.65a                  | 97.10a                 | 7.58a                         |
| Srikandi Kuning| 14.67c                   | 37.20a                  | 83.09b                 | 6.92a                         |
| Anoman         | 16.67d                   | 35.97a                  | 73.47c                 | 6.67a                         |
| KK (%)         | 6.63                     | 6.28                    | 3.08                   | 7.83                          |

Note: Average value in the same column followed by the same letter indicates insignificant different in the DMRT test at the confidence level of 95%.

The statistical data indicate that yield components in the parameter of number of seeds per row and 250 seed weight had a significant influence on treatment. Number of seeds per ear and crop cutting test result had no significant influence in the four varieties. Statistically, it could be seen that Lamuru variety had higher and significantly different number of seeds per row compared to other variety. The number of seeds per row, number of seeds per ear, and 250 seed weight were closely related to productivity. The more number of seeds in one ear produced, the more the opportunity to yield dry shelled seeds. The crop cutting test results of the four varieties had no significant influence. Based on the description, Lamuru variety had a yield potential of 7.6 ton/ha with an opportunity for improvement through the application of optimal cultivation techniques as well as supporting climate and environment factors. A research results by BPTP of Central Sulawesi in various locations, Sigi regency, Parigi Moutong, dan Donggala regency, indicated composite corn production above 6-8 ton per hectare of the crop cutting test result.

3.4 Economic Feasibility of Several Composite Corn Varieties

A variety performance can be tested through the result of growth and yield/production. The variety, however, should be economically feasible to be acceptable and then adopted by farmers. It is due to the corn farming goal that is to gain profit or income. One of feasibility indicators is R/C ratio. The analysis results in Table 5 indicate that the four treatments of composite corn varieties had an R/C ratio value greater than 1 in the range of 1.17 to 1.3. Hence, the four corn varieties were feasible to be cultivated and developed in rainfed dry land (cocoa land).

Table 5. Farming analysis results of productivity study of composite corn new superior varieties in Bulili Village, 2019

| Description       | Sukmaraga | Economic Performance (Rp.) | Lamuru | Srikandi Kuning | Anoman |
|-------------------|-----------|----------------------------|--------|-----------------|--------|
| Materials         | 10,000,000| 10,000,000                 | 10,000,000| 10,000,000     |        |
| Labor             | 11,500,000| 11,500,000                 | 11,500,000| 11,500,000     |        |
| Total Cost        | 21,500,000| 21,500,000                 | 21,500,000| 21,500,000     |        |
| Yield (t/ha)      | 8.000     | 8.000                      | 7.500   | 7.200           |        |
| Revenue           | 28,000,000| 28,000,000                 | 26,250,000| 25,200,000     |        |
| Income            | 6,500,000 | 6,500,000                  | 4,750,000| 3,700,000      |        |
| R/C               | 1.3       | 1.3                        | 1.2     | 1.1             |        |
| B/C               | 0.30      | 0.30                       | 0.20    | 0.17            |        |

Perception of composite corn development in the adaptation test area, Nokilalaki sub-district Sigi Regency, is presented in Table 6. Based on the interview results and analysis of Table 6, the composite
corn price and marketing received positive response from the farmers. The reason was that there was no difference between the price of composite corn and hybrid or local corn. There were no obstacles in the composite corn marketing and it was supported by a relatively stable shelled corn price in 2019. Regarding productivity, despite the farmers awareness of the adaptability of composite corn in the dry land, they expect that it has higher productivity; thus higher profit of composite corn farming. Farmers in Nokilalaki sub-district Sigi Regency were generally interested in the composite corn types.

Table 6. Farmers’ Perception of composite corn development in Sigi Regency, 2019

| Description                           | Score |
|---------------------------------------|-------|
| Composite corn selling price          | 3.15  |
| Composite shelled seed corn marketing | 3.35  |
| Composite corn farming profit         | 3.08  |
| Composite corn productivity           | 3.08  |
| Interest in composite corn            | 3.00  |

4. Conclusion
Conclusions could be drawn from the research results of adaptation test of several composite corn varieties include: The tested composite corn varieties (lamuru, sukmaraga, srikandi kuning, and anoman) had a significant influence for most of the crop parameters, expect ear length. Lamuru and Sukmaraga varieties produced the highest dry shelled weight of 8 t/ha and followed by Srikandi Kuning and Anoman of 7.5 t/ha and 7 t/ha, respectively. The composite corn development in dry land could utilize Lamuru and Sukmaraga varieties. The Lamuru, Sukmaraga, Srikandi kuning, and Anoman varieties were all economically feasible for dry land farming with the largest R/C ratio was Sukmaraga and Lamuru and followed by Srikandi Kuning and Anoman. Farmers in Nokilalaki Sub-district Sigi Regency Central Sulawesi were interested in planting the composite corn from Indonesia Agency for Agricultural Research and development (IAARD).

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