The agronomy performance and financial feasibility of hybrid maize varieties for consumption and cattle feed in different planting system

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Abstract. This study aimed to understand the agronomy performance and financial feasibility of young harvest hybrid maize for consumption and cattle feed in different planting system. Research was arranged by using Block Randomized Design with five treatments replicated for five times namely P1: Bima 20 URI variety by jajar legowo 2:1 planting system (100 cm x 50 cm x 20 cm and 1 seed/hole) ; P2: Bima 20 URI variety by jajar legowo 2:1 (100 cm x 50 cm x 40 cm and 2 seeds/hole) ; P3: Bima 20 URI variety by tandur jajar (80 cm x 40 cm and 2 seeds/hole) ; P4: Pertiwi variety by tandur jajar (80 cm x 40 cm and 2 seeds/hole) and P5: Pertiwi variety by farmer’s way. Results showed that the growth performance of all treatments were similar meanwhile treatments affected on the yield components. Jajar legowo 2:1 planting system in P1 and P2 increase the maize plant population up to 6.66% following by the yield increasing were 85.97% and 83.27% respectively compared to farmer’s way (P5). In additional, the carrying capacity of maize waste for cattle feed reached up to 47.13% (P1) and 43.78% (P2) by jajar legowo 2:1. The highest of B/C ratio was obtained from P2 (1.98) and P1 (1.68) by jajar legowo, following by P3 and P4 (1.59) and P5 (1.38) by tandur jajar. P1 and P2 treatments can be recommended to farmers in order to enhance the yield and income.

1. Introduction

Maize (Zea mays) also called corn is the second of important food crop after rice in developing countries particularly Indonesia. The requirements of maize increase continuously in every year [1]. The maize requirements in 2015 has been reported increasing from 28273501 ton in 2010 to 35713001 ton in 2015 [2] meanwhile maize national production in 2010 was 18327636 ton and 19.61 million ton in 2015 [3]. According to these data, it can be seen that there is gap between the production and the demand as far as the maize demand increasing for consumption, livestock feed industry and others.

The increasing of maize demand still cannot fulfilled independently therefore the import policy cannot be separated from the government’s efforts to solve this issue. The maize demand in domestic was fluctuations following the demand of livestock feed industry [4]. The reducing of planting area and the diversity of maize production in each region in Indonesia caused the maize requirement nationally was difficult to reach. In 2015, the maize productivity in West Java has reached 75.69 quintal/hectare, West Nusa Tenggara was 67.09 quintal/hectare meanwhile the maize productivity in other regions such as in Papua, West Papua, Bali, East Nusa Tenggara and others was still low below 30 quintal/hectare [5]. The maize productivity in Bali always increase however the planting area predicted tend to reduce in future. In 2014, the maize cultivation area was 19335 ha and it reduced up to more than 3000 hectare in 2018 became 16951 ha. In contrast, the maize productivity in Bali increase from 24.34 quintal/ha to 36.97 quintal/ha in 2015-2018 [6].
Buleleng Regency is the Regency with the largest area for maize cultivation. The maize harvested area in Buleleng Regency reached 6603 ha in 2015 with the maize productivity was only 31.80 quintal/ha [7]. This productivity was categorized low due to the effect of many factors namely the low of soil fertility and rainfall, the farmer’s traditionally maize cultivation habits such as the uses of local varieties, fertilization and plant population management. The maize crops were not only utilized for human consumption but also it can use for the livestock feed particularly its waste in order to supply the feed in dry season when the forage availability was limited.

In order to enhance the maize productivity, the implementation of modern agriculture practices is required to be applied such as the uses of superior maize varieties or hybrid variety, plant population management and others. The jajar legowo 2:1 planting system in maize cultivation has been widely studied and proven capable to increase the maize productivity. The jajar legowo 2:1 planting system (80 cm x 50 cm x 40 cm) with 2 seeds/hole enhance the maize productivity up to 10.64 ton/ha compared to tandur jajar planting system (70 cm x 40 cm with 2 seeds/hole) was 9.23 ton/ha [8]. The young harvest maize farming system was more profitable due to its waste also provide the benefit to farmers. The profit of old harvest maize farming system was IDR 14659000/ha and increase up to IDR 20905000 by young harvest maize farming system [9]. The increasing mentioned was caused by the additional income from the fresh maize’s waste selling. The goals of this study is to understand the agronomy performance and financial feasibility of young harvest hybrid maize for consumption and cattle feed in different planting system.

2. Materials and Methods

2.1 Research Design

Research was carried out at Subak Palbesi, Gerokgak Village, Gerokgak District, Buleleng Regency, Bali Province from May to August 2019. Research was arranged by using Block Randomized Design with five treatments replicated for five times as informed in Table 1.

**Table 1.** The treatments and cultivation practices of two young harvest hybrid maizes with different planting system in Gerokgak Village, Gerokgak District, Buleleng Regency, Bali in 2019.

| Number | Description | Note |
|--------|-------------|------|
| 1.     | Varieties   | Bima 20 URI and Pertiwi |
| 2.     | Cultivation practices | Perfect tillage |
|        | a. soil management | P1: Bima 20 URI variety by jajar legowo 2:1 planting system (100 cm x 50 cm x 20 cm with 1 seed/hole). Population density was 66666 plants/ha |
|        | b. planting as treatments | P2: Bima 20 URI variety by jajar legowo 2:1 planting system (100 cm x 50 cm x 40 cm with 2 seeds/hole). Population density was 66666 plants/ha |
|        |             | P3: Bima 20 URI variety by tandur jajar planting system (80 cm x 40 cm with 2 seeds/hole). Population density was 62500 plants/ha |
|        |             | P4: Pertiwi variety by tandur jajar planting system (80 cm x 40 cm with 2 seeds/hole). Population density was 62566 plants/ha |
|        | c. fertilization | P5: Pertiwi variety by farmer’s traditionally maize farming habits. Population density was 64000 plants/ha |
|        |             | The total land for maize cultivation was 1 ha by using farmer’s land |
|        |             | P1-P4 treatments: |
The organic fertilizer fermented (cattle manure) was applied for 2.5 ton/ha.

Urea (250 kg/ha) and NPK (250 kg/ha) fertilizer were given at 14-21 Days After Planting (DAP) and 36 DAP by tugal method.

P5 treatment

- Only given the Urea fertilizer (250 kg/ha) in once at 21 DAP

d. plant pest and disease management

Controlled by implementation of integrated pest management

e. irrigation

Inundation/flood irrigation

f. weed management

Weeds were controlled by using mechanical equipment (hoe) before Urea and NPK fertilization

3. Harvesting

Maize crops were harvested at young age mainly at 80 DAP or depending the maize’s variety age.

2.2 Data Collection

Data collected were derived from variables observed namely the agronomy performance consisted of growth performance (plant height, number of leaves per plant, maize stover weight per plant, maize stover weight per ha) and yield (number of maize cob per plant, maize cob weight with its husk per plant, weight of peeled maize cob per plant and weight of peeled maize cob per ha).

The maize stover weight per ha and weight of peeled maize cob per ha were calculated by converting the yield in frame area into the yield per hectare following this equation:

\[
\text{The maize stover weight per ha} = \frac{10000^2}{\text{frame area (m}^2\text{)}} \times \text{maize stover weight in frame area (kg)} \times \frac{1}{1000} \times 1 \text{ ton}
\]

\[
\text{Peeled maize cob weight/ha} = \frac{10000^2}{\text{frame area (m}^2\text{)}} \times \text{peeled maize cob weight in frame area (kg)} \times \frac{1}{1000} \times 1 \text{ ton}
\]

The frame area for jajar legowo 2:1 planting system was 3 m x 2.4 m (6.8 m^2), tandur jajar was 3.2 m x 2 m (6.4 m^2), farmer’s traditionally maize farming was 2.5 m x 2.5 m (6.25 m^2). The carrying capacity of maize waste for cattle feed potential was computed by following this equation:

\[
X = \frac{A}{B}
\]

Note:
X= The carrying capacity of maize waste for cattle feed potential
A= The maize stover weight per ha (kg)
B= The cattle feed requirement per day (kg/ekor)
2.3 Data Analysis
The agronomy data was calculated by using variance analysis (ANOVA) and LSD 5% (P value < 0.05). The profit income of maize farming system was calculated by following this equation:

\[ I = P \times Q - TC \]

Note:
I= The profit income (IDR)
P= The production price per unit (IDR)
Q= Number of production
TC= Number of production cost

The Financial feasibility was calculated by using financial feasibility analysis (B/C ratio). If B/C ratio > 0, the farming system was feasible to be adopted and if B/C ratio > 1, it was not suggested to be adopted. Furthermore, the carrying capacity of maize waste for cattle feed potential were determined according to the standard of cattle forage requirement was 10% from cattle weight.

3. Results and Discussion
3.1 The Agronomy Performance of Maize Crops
The difference planting system namely jajar legowo and and tandur jajar were not significantly influenced to plant height and number of leaves per plant meanwhile it greatly influenced to the maize stover weight produced. The maize stover weight by jajar legowo 2:1 and tandur jajar planting system (P1, P2, P3 and P4) were similar to each other. In contrast, variables mentioned of P1, P2, P3 and P4 treatments were significantly different to P5 treatment (Table 2). It was possibility caused by farmer’s traditionally maize farming habits particularly the fertilization as described in Table 1.

| Treatments | Plant height (cm) | Number of leaves per plant | Maize stover weight per plant (gr) | Maize stover weight per ha (ton) |
|------------|------------------|----------------------------|-----------------------------------|----------------------------------|
| P1         | 258.70 a         | 13.50 a                    | 499.00 b                          | 26.75 c                          |
| P2         | 257.80 a         | 13.60 a                    | 495.00 b                          | 26.14 c                          |
| P3         | 258.60 a         | 13.50 a                    | 487.00 b                          | 22.92 b                          |
| P4         | 262.00 a         | 13.40 a                    | 485.00 b                          | 23.31 b                          |
| P5         | 250.50 a         | 12.80 a                    | 317.50 a                          | 18.18 a                          |

Noted: Numbers followed by the same letters in same coloumn were not significantly different at DMRT 5%.

The maize crops growth performance of all treatments were similar meanwhile treatments affected on the yield components (Table 3). P1 and P2 treatments produced the highest peeled maize cob weight per ha than others. Meanwhile, P5 treatments produce the lowest values in all yield components variables observed (Table 3).
Table 3. The yield components of young harvest hybrid maize cultivated with different planting system in Gerokgak Village, Gerokgak District, Buleleng Regency, Bali 2019.

| Treatments | The maize cob with its husk weight/plant (gram) | Number of maize cob per plant | Peeled maize cob weight per plant (gr) | Peeled maize cob weight per ha (ton) |
|------------|-----------------------------------------------|-------------------------------|--------------------------------------|----------------------------------|
| P1         | 350.40 b                                      | 1.00 a                        | 208.00 b                             | 11.01 c                          |
| P2         | 345.70 b                                      | 1.00 a                        | 205.70 b                             | 10.85 c                          |
| P3         | 344.00 b                                      | 1.00 a                        | 204.20 b                             | 9.93 b                           |
| P4         | 345.40 b                                      | 1.00 a                        | 204.80 b                             | 9.92 b                           |
| P5         | 215.50 a                                      | 1.00 a                        | 115.00 a                             | 5.92 a                           |

Noted: Numbers followed by the same letters in same columnn were not significantly different at DMRT 5%.

The maize stover weight with cattle manure fertilization was heavier than without cattle manure fertilization [10]. The availability of soil nutrients were highly affected to the growth and development of maize crops proven with the low of maize growth and yield by farmer’s traditionally maize farming habits (P5) mainly the single fertilization habits (only urea fertilization without NPK fertilizer addition). If the crops capable to growth well in vegetative phase, it can initiate the growth well in generative phase lead to the good production. Application of cattle manure fertilizer can improve the soil structure by increasing its infiltration, hydraulic, organic carbon, conductivity, available water capacity, size of aggregates, and decreasing bulk and particle density [11]. The organic matter of cattle manure allows plants to use the soil nutrients for long period due to it is slow decompositions and reduces the loss of what is not utilized by plants [12]. The decomposition of organic materials can be used as energy source for soil microorganisms [13, 14] to stimulates their biological activity in forming the soil pores that increase soil porosity, water infiltration and soil water capacity and to stabilize soil structure by bonding organic materials to soil minerals. The application of urea fertilizer in once planting season cause the low supplying of N nutrient to the plants impacted on biochemical and physiological functions of plant [15]. Nitrogen, phosphorous and kalium are critical determinants of plant growth and productivity. Phosphorus (P) is categorized as one of primary nutrient for plant growth and is required to sustain optimum plant production and quality. The P element is essential for cell division, reproduction and plant metabolism. Its role is related to the acquisition, storage, and use of energy [16]. Furthermore, Potassium (K) nutrient has been shown to improve disease, biotic and abiotic stresses resistance in plants, improve the size of grains and seeds and improve the quality of fruits and vegetables. K nutrient promotes the translocation of photosynthesis (sugars) for plant growth or storage in fruits or roots. K also assists in regulating the plant’s use of water by controlling the opening and closing of leaf stomata [17, 18, 19].

The planting space contribute to influence the growth and development of crops production. The light interception of crops can be altered by planting spacing management. Light interception can be increased by closer row plant spacing such as jajar legowo therefore the crops obtain more sunlight to be processed into ATP and NADPH for use in CO2 assimilation and other synthetic metabolisms [20]. The maize cob weight represented the source-sink ratio from the whole grain filling period. The changes in source–sink ratio during grain filling period in maize are frequently accompanied by extremely changes in maize stover dry weight as the supply of assimilates by the source and the demand by the sinks are buffered by assimilates temporarily stored in the stover [21].
The cultivation by jajar legowo planting system allowed more plants to be border plant [22]. Border plant capable to grow and develop better than plants grow in the middle following by better production therefore the more border plants effect in cultivation area, the yield obtained can increase [23]. The jajar legowo planting system capable to increase the population density number of maize crops (66666 plants/ha) compared to tandur jajar (62500 plants/ha) and initiate the maize productivity increasing [24]. On other hand, the population density of maize crops was 140000 plants/ha cause the reducing of growth and yield rather than having density population of 60000-80000 plants/ha [1] due to the plants compete to obtain the vital resource to grow and develop well. The maize yield can be boosted by increasing the planting density even though it also has been reported that excessive density can also cause yield loss because of intra-specific competition [25]. This suggested that moderately high population densities maize crops may be useful to minimize intra-specific competition to achieve higher grain production [26]. The increasing of maize plant density in other field experiment was associated with an increase of fresh and dry biomass yield [27]. The plants density population hold the role to influence on physiological indices of hybrids maize as crop growth rate, relative growth rate, total dry matter, net assimilation rate and leaf area index [28]. The utilization of Bima 20 URI and Pertiwi varieties as hybrid maize variety with same planting system (tandur jajar) were not significantly affected on the growth and yield of maize crops. It suggested that crop production ability was associated with the genetic factor and adaptation ability to environmental factors. The more positively these factors relationship created, the more yield will be produced.

3.2 The Carrying Capacity of Maize Crops Waste for Cattle Feed

Maize crops waste in form of its stover is the beneficial organs besides of its cob particularly when it harvested at young age. It can be utilized to substitute the cattle forage feed. The increasing of maize crops population density was associated with the increasing of maize crops waste. In line with the assumption that all maize crops waste can be used for cattle feed, the P1 treatment capable to provide the cattle feed for 1070 cows, following by P2 (1046 cows), P3 (917 cows), P4 (932 cows) and P5 (727 cows) as demonstrated in Table 4.

Table 4. The carrying capacity of hybrid maize crops waste harvested at young age with different planting system in Gerokgak District, Buleleng Regency, Bali 2019.

| Number | Description                      | Treatment |
|--------|----------------------------------|-----------|
| 1      | Waste potential per ha (kg)      | P1 26750  |
| 2      | The carrying capacity of waste per stover |
|        | 100% for cattle feed (cows)      | P2 26140  |
|        | 50% of forage feed substitution (cows) | P3 22920  |
|        |                                  | P4 23310  |
|        |                                  | P5 18180  |
| 2      | 1070                             | P2 1046   |
|        | 917                              | P3 917    |
|        | 932                              | P4 932    |
|        | 727                              | P5 727    |

Note: According to the assumption that forage feed requirement for cattle (cow) was 10% from its weight (250 kg) = 10% x 250 kg = 25 kg/head/day.

The utilization of maize crops waste as cattle feed is highly suggested for feed availability sustainable due to it can help farmers reduce the feed cost and its availability was not compete with human and other livestock feed requirements. The maize crops harvested at young age particularly while the crops is still green, it provides a large residue yield with the high quality of roughage. The maize crops waste from such plants is superior feed rather than residue fully mature crops [29]. The nutrient composition of maize crops waste (maize stover) on fresh and dried condition was clearly explained in Table 5 [29].
Table 5. Nutrient composition of maize crops waste (maize stover) on fresh and dried condition [29].

| Nutrient value       | Unit           | Corn stover | Dried | Fresh |
|----------------------|----------------|-------------|-------|-------|
| Dry matter           | % as fed       | 92.9        | 28.9  |
| Crude fiber          | % DM           | 42.4        | 30.1  |
| Crude protein        | % DM           | 3.7         | 6.9   |
| ADF                  | % DM           | 53.2        | 35.9  |
| NDF                  | % DM           | 82.4        | 65.5  |
| Ether extract        | % DM           | 0.6         | 1.2   |
| Total sugars         | % DM           | 17.9        | 18.1  |
| Ash                  | % DM           | 6.6         | 6.7   |
| Calcium              | g/kg DM        | 2.9         | 3.7   |
| Gross energy         | MJ/kg DM       | 92.9        | 28.9  |
| Potassium            | g/kg DM        | 13.6        | 18.7  |
| Phosphorus           | g/kg DM        | 0.7         | 2.0   |

Source: [29].

The cattle was given 50% maize residue combined with groundnut foliage for its feed capable to increase the cattle’s weight up to 0.50 kg/head/day with FCR was 8.70 [30]. The growth of cattle with addition of 100% sweet maize residue and 1 kg pollard as feed supported by growth promotor injection was 9.92% higher than control [31]. In agreement with [32] the application of 50% maize crops waste as feed combined with growth promotor create the increasing of daily cattle weight was 0.56 kg/head/day.

The maize crops waste (maize stover) has the weakness as cattle feed namely it contains highly crude fiber. Because of that, it was strongly recommended to process its wasted become preserved feed before given to the cattle. Table 6 [33] informed that the maize crops waste processed to be silage has higher protein nutrient than unprocessed maize crops waste. In order to optimize the cattle growth, it require the combination of maize waste crops, forage and growth promotor. The nutrient composition, consumption behavior and feed types influence to the cattle’s growth [34].

Table 6. Nutrient composition of maize crops waste in each part [33].

| Parts                 | DM | TDN | CP | UIP | CF | ADF | NDF | CF | As h | Ca | P |
|-----------------------|----|-----|----|-----|----|-----|-----|----|------|----|----|
| Maize straw           | 80 | 67  | 9  | 45  | 25 | 29  | 48  | 2.4| 7    | 0.50| 0.25|
| Maize stover          | 80 | 59  | 5  | 30  | 35 | 44  | 70  | 1.3| 7    | 0.35| 0.19|
| Unmature maize silage | 26 | 65  | 8  | 18  | 26 | 32  | 54  | 2.8| 6    | 0.40| 0.27|
| Fully mature maize silage | 34 | 72  | 8  | 28  | 21 | 27  | 46  | 3.1| 5    | 0.28| 0.23|
| Sweet maize silage    | 24 | 65  | 11 | -   | 20 | 32  | 57  | 5  | 5    | 0.24| 0.26|
| Maize cobs            | 90 | 48  | 3  | 70  | 36 | 39  | 88  | 0.5| 2    | 0.12| 0.04|

Note: DM= dry matter ; TDN= total digestible nutrient ; CP= crude protein ; UIP= Undegradable insoluble protein ; CF= crude fiber ; ADF= acid detergent fiber ; NDF= neutral detergent fiber ; Ca= calcium ; P= phosphorus.
3.3 The Financial Feasible Analysis

Financial feasible analysis showed that the increasing of income and profit farming system was occurred in jajar legowo 2:1 planting system rather than tandem jajar planting system and farmer’s traditionally farming habits. The income acceptance was obtained from the corn cob and corn stover selling. The highest income acceptance was produced by P1 treatment rather than P2 treatment and others. On the contrary, P2 treatment create the highest profit than P1 treatment and others (Table 7). It possible caused by the labor cost and plant fertilization in P2 treatment was more efficient. Generally, jajar legowo 2:1 planting system as (P1 and P2 treatments) were more capable to provide higher income acceptance and profit than tandur jajar planting system (P3 and P4 treatment). It was related to the increasing of maize crops productivity initiated by the higher maize crops population density therefore income obtained was also higher.

Table 7. Financial feasible analysis of hybrid maize crops farming system with different planting system in Gerokgak Village, Buleleng Regency, Bali, 2019.

| Description                      | Treatment       |
|----------------------------------|-----------------|
|                                  | P1              | P2              | P3              | P4              | P5              |
| 1 Labor cost (IDR)               | 4720000         | 12320000        | 13120000        | 13120000        | 9920000         |
| 2 Production cost (IDR)          | 5725000         | 5725000         | 5725000         | 5800000         | 3075000         |
| 3 Total cost (IDR)               | 20445000        | 18045000        | 18845000        | 18920000        | 12995000        |
| 4 Income acceptance (IDR)       | 54740000        | 53856000        | 48888000        | 49004000        | 30952000        |
|                                  | - Peeled maize cob (IDR) | 44040000        | 43400000        | 39720000        | 39680000        | 23680000        |
|                                  | - Maize stover (IDR) | 10700000        | 10456000        | 9168000         | 9324000         | 7272000         |
| 5 Profit                         | 34295000        | 35811000        | 30043000        | 30084000        | 17957000        |
| B/C ratio                        | 1.68            | 1.98            | 1.59            | 1.59            | 1.38            |

Even though the population density in traditionally maize crops farming by farmers (64000 plants/ha) was higher than tandur jajar planting system (62500 plants/ha), it produced the lowest of profit and B/C ratio than P1, P2, P3 and P4 treatments. P5 treatments namely farmer’s traditionally maize crops farming habits create the lowest maize productivity than others particularly effect of the single fertilization (urea only). Nevertheless, B/C ratio obtained from all treatments were feasible to conduct because of the B/C ratio > 1. The higher B/C ratio obtained, it will more efficient to conduct [35]. The efficiency of farming system can be determined by the output, input, outcome and income were balance [36].

4. Conclusions

The maize crops growth performance of all treatments were similar meanwhile treatments affected on the yield components. Jajar legowo 2:1 planting capable to increase the maize crops population density up to 6.66% following by the increasing of maize productivity and waste production. The income acceptance, profit and farming system efficiency in maize crops by jajar legowo planting system (P1 and P2) were higher than tandem jajar (P3 and P4) and farmer’s traditionally maize crops farming habits (P5). The maize crops farming system by jajar legowo 2:1 planting system (P1 and P2) was more efficient and feasible because of the highest B/C ratio was found in P2 and P1 treatments compared to tandem jajar and farmer’s way namely 1.68 (P1), 1.98 (P2), 1.59 (P3 and P4) and 1.38 (P5). P1 and P2 treatments can be recommended to farmers in order to enhance the yield and income.
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Authors Contribution Statement

The main contributor were I Nyoman Adijaya and Ni Luh Gede Budiari and supporting contributors were Anella Retna Kumala Sari and Putu Sweken Elizabeth. Main contributors contribute to conceptualization, methodology, data analysis, validation the research outputs and writing the manuscript. Supporting contributors play role in field observation, data collecting and help the main contributors to write the manuscript.

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