Adaptation of superior maize varieties high yield and biomass the availability of animal feed

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Abstract. Maize is the second important commodity after rice in Indonesia. The application of high yielding varieties is one of the best strategies to increase productivity in maize development areas. The aim of the study was to obtain superior varieties with the highest yield potential and biomass to increase productivity and its availability as animal feed. The research was conducted in Pringgabaya district, East Lombok Regency, West Nusa Tenggara from April to June 2020. The field experiment used a randomized block design with treatment of 8 hybrid varieties, where six new superior varieties (Bima-14, Bima 20, HJ-21, JH-27, JH-37, Nasa-29) and two comparison varieties (Bisi-2 and Pioner 21), each treatment was repeated four times. The results showed that there were 3 high yielding hybrid maize varieties, namely JH-37 (8.43 t/ha), Nasa-29 (8.35 t/ha) and HJ-21 (8.15 t/ha) significantly differ from other varieties. For the highest biomass potential, there are 3 superior varieties of hybrid maize, namely HJ-21 (4.82 t/ha), Bima-20 (4.69 t/ha) and JH-27 (4.56 t/ha). High yielding hybrid maize varieties that available as animal feed were JH 37, Nasa-29 and HJ-21.

1. Introduction
Corn is the second important food commodity after rice in Indonesia. In addition to being a food commodity, corn is an important raw material for animal feed [1]. According to Tangendjaja et al., (2003), 51% of maize is used as animal feed. Corn consumption for feed tends to increase with an average annual growth of 11.52%, while production growth is only 6.11% [2]. The demand for corn for food, feed, and other industrial needs will continue to increase. The government has implemented various policies and programs to increase corn production so that domestic needs can be fulfilled. Government programs in order to increase corn production and productivity through specific technology, and the use of new superior varieties [3].

Indonesia’s corn production in 2020 is 24.95 million tons of dry shelled, with a productivity of 4.54 tons/ha [3]. Indonesian corn productivity is still low when compared to the potential yield of hybrid corn reaching 10 – 13 tons/ha. Efforts made to increase corn productivity quickly and easily are the use of high-yielding varieties. The success of the cultivation of a plant commodity is influenced by many factors, one of which is the selection of plant varieties to be developed [4]. The application of superior varieties is one of strategies to increase crop production. The increase in production is expected to maintain a balance between the availability and demand for a commodity in the market. However, what needs to be considered in the use of varieties is the adaptability of each variety to the conditions of the agro-ecosystem, both climate and environment where the variety is cultivated. The adaptability of a
variety to the environment in which it is developed, determines whether the variety is suitable for development [5].

Along with the increase in national corn production, indirectly increase the corn biomass production, and the biomass is related to livestock feed needs. Corn biomass is all by-products of corn production activities, such as stems, leaves, cob husks, and cob. Corn by-products that are commonly found are stover (stems and leaves) and cob which range from 50-73% of all maize yields [6,7]. Corn biomass is generally used as a source of animal feed [8].

The availability of quality forage, especially in the dry season is one of the problems in the development of livestock (ruminants). Other problems in developing animal feed sources include the availability of local feed that is not continuous, the application of forage feed technology is still low, and the quality of the feed produced does not meet the standards [9]. Therefore, it is necessary to manage biomass in order to increase the nutritional quality and the storage of the feed produced [10].

West Nusa Tenggara (WNT) is one of the corn producing provinces in Indonesia. Corn and livestock are the main commodities of WNT. WNT corn production in 2020 [3] is 1.66 million tons with a low productivity level of 5.87 tons/ha. Corn productivity can be increased, one of which is through the use of new high yielding varieties. The Ministry of Agriculture has produced many superior varieties with high yield potential and stay green (producing high biomass for animal feed). This new superior variety needs to be adapted at the farmer level to determine the potential yield that can be achieved. It is hoped that from this adaptation, adaptive maize varieties will be obtained that have high yield potential to increase maize production in WNT and Indonesia.

In addition to corn seeds, the by-product in the form of biomass is very potential to be used as animal feed. So far, the by-product of corn has not been optimally utilized by cattle farmers for animal feed. While the potential yield of maize biomass is very high, especially in the maize development area. In dry conditions, livestock farmers often experience a shortage of feed. Livestock farmers have to go far to get animal feed.

From this condition, it is very good if there is integration between corn and cattle, so that the supply of feed for cattle is available. For this reason, there needs to be research on the use of new varieties, which have high yield potential and high biomass for animal feed. The Agricultural Research and Development Agency has produced many new superior varieties that have high yield potential and high biomass, which are called stay green. This variety needs to be adapted to farmers' land, to find out the potential yields achieved. Therefore, the aim of the research is to obtain new varieties with the highest yield and biomass to increase productivity and availability of animal feed.

2. Materials and Methods

The research was conducted on farmer's land in Seruni Mumbul Village, Pringgabaya sub districts, East Lombok districts, West Nusa Tenggara Province. The study was conducted in the dry season, from April to June 2020. The research location is lowland with dry land agroecosystem. The source of irrigation from wells. This location is a maize development area in East Lombok Districts. The genetic material used is a national hybrid corn variety released by the Ministry of Agriculture.

The study used a randomized block design, with treatment of 8 hybrid varieties, namely 6 new high yielding varieties (Bima 14, Bima 20, HJ 21, JH 27, JH 37, Nasa 29) and 2 commercial varieties commonly grown by farmers as comparisons (Pioner 21 and Bisi 2) which is repeated 4 times. There were 8 treatment units and each treatment unit was repeated 4 times, so there were 32 treatment units.

Cultivation of land with minimum tillage. Planting using the manual method, with a spacing of 70 cm x 20 cm, 1 seed per hole. Organic fertilizer is given as much as 1 ton/ha, which is applied as a cover for planting holes. The first standard fertilizer was given at the age of 10 days after planting (DAP) with a dose of urea 50 kg/ha + NPK 250 kg. The second fertilizer was given at the age of 30 DAP with a dose of Urea 200 kg/ha. Weeding was carried out at the age of 21 days after planting using a selective herbicide after growth. Watering was carried out 6 times during the growing season. Control of plant pests and diseases is carried out if there is an attack in the field. Harvesting is done when the plant is 102 days old.
Observed variables; dry seed yield (t/ha), length of cob (cm), diameter of cob (mm), number of rows/cob (row), number of seeds/row (seeds), number of seeds/cobs, weight of 100 seeds (g), weight cob husk (kg/ha), cob weight (kg/ha), dry stover weight (kg/ha), and total biomass weight (kg/ha).

Observation data were analyzed using variance (ANOVA) using the Minitab version 16 program and the average difference test using the honest real test (BNJ / Tukey) at the 95% confidence level (α = 0.05).

3. Result and Discussion

3.1. Yield Components and Maize Yield

The results of the analysis in Table 1 that the yield of each corn variety was significantly different. The highest yield was JH 37 (8.43 t/ha) which was not significantly from Nasa 29 (8.35 t/ha) and HJ 21 (8.15 t/ha) but was significantly from other varieties, including comparison varieties Pioneer 21 (7.40 t/ha) and Bisi 2 (6.21 t/ha). This indicates that the new superior varieties adaptable to several conditions with high production compared to commercial varieties that are commonly grown by farmers. From these results, the three new superior varieties can be developed in maize production areas in the same agro-ecosystem.

The difference in dry seed yield between varieties is due to genetic factors and different adaptability. According to [11] that each variety has different resistance, some plants can adapt quickly but some plants take a long time to adapt to the environment. Each variety has a different genetic potential in responding to the environment in which it lives. The environment can also cause the various traits that appear from a plant. A variety has the ability to provide high yields, but if the environmental conditions are not suitable then the variety cannot show its potential yield. According to [12] that each variety has differences in its ability to sustain life and individual growth from different climates. Plant genetic factors and how they adapt to the environment can cause different growth. Each hybrid shows different growth and yields, as a result of genetic and environmental influences, where genetic influence is the influence of heredity possessed by each line while environmental influence is the influence caused by habitat and environmental conditions. Differences in phenotypes of various hybrid varieties (differences in some observed variables) are caused by genetic and environmental influences. The different genes of each variety have different characters. The environment plays a role in the appearance of the actual character contained in the gene.

The results are the same as [13] that genetic factors are one of the most influential factors on the components of maize yields. The development of varieties that have adaptability in accordance with the environment is carried out by the introduction of new high-yielding varieties. [14] also stated that the ability of a variety will provide higher production if the environmental conditions for its growth are optimal. According to [15] the difference in seed yields in corn plants is caused by genetic influences. Increasing maize production on land will be more successful when using adaptive maize varieties. According to [16] that different genotypes will give different responses even in the same environment. The use of new high yielding varieties combined with the use of appropriate fertilizers contributes to the increase in maize production. According to [17] that the filling of corn cobs is influenced by the supply of nutrients to form assimilate during the period of growth and filling of the cobs. With sufficient assimilate supply, the growth of cobs and filling of seeds is optimal so as to increase corn productivity.

The length of cob in each variety also showed a significant different. The variety with the longest cob was Nasa-29 (18.32 cm), followed by JH-37 (17.12 cm), Bima 20 (17.07 cm), and Bisi-2 (17.07 cm), which was significant from other varieties. The length of the cob has a significant on increasing the dry seed yield of corn. This shows that the four varieties have good adaptability to their environment. According to research by [18] that plant varieties are able to optimally utilize environmental factors so as to obtain sufficient nutrients, water, sunlight and have a wider space for growth and development of their roots. The appearance of a character will be optimal in this case the length of the cob on corn if the plant is in a suitable environment, otherwise the appearance will not be optimal if it is in an unsuitable environment. The appearance of a character with high heritability has little environmental influence so
that his appearance will be relatively constant, but a character with low heritability has a large environmental influence so that his appearance is easy to change.

The diameter of the cob is affected by the variety. Varieties that have a wide cob diameter are JH-37 (4.70 mm), Bima-20 (4.70 mm), HJ-27 (4.70 mm) and HJ-21 (4.62 mm) significantly different from other varieties, including the comparisons of Pioner-21 and Bisi-2. This indicates that each variety has different adaptability to its environment. Varieties that have good adaptation will have a larger diameter of the cob.

Table 1. Dry grain yield and yield components of 8 high yielding maize varieties in Pringgabaya Sub District, East Lombok, West Nusa Tenggara in 2020.

| Varieties  | Dry seed yield (t/ha) | Length of cob (cm) | Diameter of cob (mm) | Number of rows/cob (row) | Number of seeds/row (seed) | Number of seeds/cob (seed) | Weight of 100 seeds (g) |
|------------|-----------------------|-------------------|----------------------|--------------------------|--------------------------|--------------------------|------------------------|
| Bima-14    | 7.15 abc              | 16.52 b           | 4.40 de              | 14.00 bcd                | 33.72 c                  | 472.00 b                  | 41.15 a                |
| HJ-27      | 7.25 abc              | 16.67 b           | 4.70 a               | 13.60 bcd                | 36.27 b                  | 493.25 b                  | 38.64 ab               |
| Bima-20    | 7.08 bc              | 17.07 ab          | 4.70 a               | 14.27 abc                | 34.72 bc                 | 496.00 b                  | 39.51 ab               |
| HJ-37      | 8.43 a               | 17.12 ab          | 4.72 a               | 15.47 a                  | 35.47 bc                 | 548.00 a                  | 36.30 b                |
| HJ-21      | 8.15 ab              | 16.12 b           | 4.62 ab              | 14.20 abcd               | 36.27 b                  | 513.25 ab                 | 37.77 ab               |
| Nasa-29    | 8.35 ab              | 18.32 a           | 4.35 e               | 12.92 cd                 | 39.00 a                  | 503.75 ab                 | 37.67 ab               |
| Pioner-21  | 7.40 abc             | 16.32 b           | 4.57 bc              | 14.92 ab                 | 34.92 bc                 | 522.00 ab                 | 36.01 b                |
| Bisi-2     | 6.21 c               | 17.07 ab          | 4.47 cd              | 12.80 d                  | 36.92 ab                 | 472.75 b                  | 37.51 ab               |

Note: The numbers followed by the same letter in each of the same columns are not significantly different according to the BNJ/HSD Test (Tukey) at the 95% confidence level (α = 0.05).

Varieties also significantly the number of rows per cob, the variety with the highest number of rows per ear was JH-37 (15.47 rows) and significantly from other varieties, including the comparison varieties Pioner-21 and Bisi-2. This shows that HJ-37 has better adaptability compared to other varieties. The number of rows per cob has a significant on increasing grain yield. HJ-37 is one of the varieties that can be recommended to be developed in the study location and corn production area which has the same agro ecosystem as the research location.

The number of seeds per row is also affected by the variety. The Nasa-29 variety had the highest number of seeds per row (39 seeds) compared to other varieties including Pioner-21 (34.92 seeds) and Bisi-2 (36.92 seeds). This shows that the Nasa-29 variety has a good adaptability compared to Pioner-21 and Bisi-2 which are commonly grown by farmers in the research location. The differences are thought to be caused by genetic factors shared by each variety and environmental factors. According to [19] that each variety has a genetic composition that is not the same and the ability of the variety itself to adapt to its growing environment, so that it still produces good growth and maximum yields. [20] said that the number of seeds in the row affects corn production, furthermore [21] stated that the increase in the number of seeds in the row is also closely related to the amount of photosynthate that is flowed to the cob for the formation of the number of seeds. Based on the results of this study, the Nasa-29 variety is one of the varieties that can be recommended to be developed in a corn production area that has the same agro-ecosystem as the research location.

Varieties significantly the number of seeds per cob, the JH-37 variety had the highest number of seeds per cob (548 seeds), which was different from other varieties including the comparison Pioner-21 (522 seeds) and Bisi-2 (472.75 seeds). The JH-37 variety is one of the varieties that has good adaptation to the research location.

The weight of 1000 grains, significantly influenced by the variety, the variety with the heaviest weight of 100 grains was Bima-14 (41.15 g) which was significantly different from other varieties, including the comparison Pioner-21 (36.01 g) and Bisi-2 (37.51 g). This shows that the Bima-14 variety has a larger seed size compared to other varieties. The high weight of 100 seeds did not have a linear effect on increasing maize grain yield in this study.
Each yield component has a different effect on increasing maize grain yield. To find out which yield components have a positive effect on increasing maize grain yields, a correlation analysis was carried out, as shown in Table 2.

Correlation analysis was carried out to determine the effect of the interaction between yield components and corn dry seed yield (productivity). From the results of the correlation analysis in Table 2, it is known that the component that affects the grain yield of corn is the length of the cob with a correlation value of 0.395, followed by the number of seeds/rows with a correlation value of 0.326 and the number of seeds/cobs with a correlation value of 0.224. The longer the cob the more seeds per row, which affects the number of seeds per cob. In accordance with the results of research by [21] that the character of the cob that determines the yield of seeds, one of which is the length of the cob. Cob length was positively correlated with yield potential with a correlation value of 0.83, the longer the cob the higher the yield potential. According to [22] cob length was positively correlated with yield. Likewise, according to [23] if the average cob length of a variety is longer than other varieties, then that variety has the opportunity to have higher yields than other varieties.

Table 2. Correlation between dry seed yield, and yield components of 8 new high yielding varieties of maize in Pringgabaya Sub District, East Lombok, West Nusa Tenggara in 2020.

| Variabel               | Dry seed yield (t/ha) | Weight of 100 seeds (g) | Length of cob (cm) | Diameter of cob (mm) | Number of rows/cob (row) | Number of seeds/row (seed) | Number of seeds/cob (Seed) |
|------------------------|-----------------------|-------------------------|--------------------|----------------------|--------------------------|---------------------------|--------------------------|
| Weight of 100 seeds    | 0.158                 |                         |                    |                      |                          |                           |                          |
| p-value                | 0.387                 |                         |                    |                      |                          |                           |                          |
| Length of cob (cm)     | **0.395**             | **0.233**               |                    |                      |                          |                           |                          |
| p-value                | 0.025                 | 0.199                   |                    |                      |                          |                           |                          |
| Diameter of cob (mm)   | -0.084                | 0.032                   | -0.165             |                      |                          |                           |                          |
| p-value                | 0.647                 | 0.862                   | 0.368              |                      |                          |                           |                          |
| Number of rows/cob     | -0.008                | -0.108                  | -0.172             | 0.522                |                          |                           |                          |
| p-value                | 0.965                 | 0.557                   | 0.346              | 0.002                |                          |                           |                          |
| Number of seeds/row    | **0.326**             | 0.000                   | **0.536**          | -0.207               | -0.457                   |                           |                          |
| p-value                | 0.069                 | 0.999                   | 0.002              | 0.256                | 0.008                    |                           |                          |
| Number of seeds/cob    | **0.224**             | -0.118                  | 0.185              | **0.437**            | **0.766**                | 0.221                      |                          |
| p-value                | 0.217                 | 0.519                   | 0.310              | 0.012                | 0.000                    | 0.225                      |                          |

Note: Pearson correlation
P-Value

In addition, the components also interact with each other. Where the number of rows per cob has the highest positive correlation (R = 0.766) to the number of seeds per cob, the higher number of seeds per row the higher number of seeds per cob. This is in accordance with [23] that the number of seed rows affects the potential yield with a positive correlation but at a very weak level (R = 0.08). A higher number of seed per rows is assumed to have more number of seeds so that the potential yield increases.

The diameter of the cob has a positive interaction with the number of rows per cob (R = 0.522). This means that the larger the diameter of the cob, the higher the number of rows per cob. In addition, the diameter of the cob was also positively correlated (R = 0.437) with the number of seeds per cob. The larger the diameter of the cob, the greater the number of seeds per cob. Of course, varieties with large cob diameters will have higher yield potential. This is in accordance with the results of research by Agustin, E., dan Sugiharto A. N. (2017) another important cob character is the diameter of the cob. Cob diameter was positively correlated with grain yield (R = 0.78). The wider the diameter of the cob, the higher the yield potential. This is because the wider the cob diameter causes the number of seeds to increase so that the potential yield is higher.

Cob length was positively correlated with the number of seeds per row (R = 0.536), the longer the cob, the more seeds per row. Therefore, varieties with longer cobs and larger diameters will have higher yield potential.
3.2. Maize Biomass

West Nusa Tenggara Province has superior commodities, namely corn and cattle. In the dry season, livestock farmers find it difficult to get grass feed on grazing land due to drought. To overcome this problem, farmers usually use corn biomass. The part of the corn plant used as cattle feed in West Nusa Tenggara is the stem and leaves that are above the cob before the corn harvest or often called biomass. Meanwhile, corn husks and corn cobs have not been used optimally by farmers as cattle feed.

From Table 3, it is known that variety has a significant effect on corn husk weight. Where JH-37 had a higher corn husk weight (1,352 kg/ha) followed by Nasa-29 (1,274 kg/ha) and significantly different from other varieties including Comparation Pioner-21 and Bisi-2. This shows that JH-37 and Nasa-29 have the opportunity to be developed in the maize and cattle area, suitable to be developed in areas that have integration of corn with cattle.

For corn cob weight is also influenced by variety, where the varieties with the highest cob weight were HJ-27 (3,619 kg/ha) and HJ-21 (3,524 kg/ha) which were significantly different from other varieties including Comparator Pioner-21 and Bisi-2. The variety that had the lowest clump weight was the Nasa-29 variety. This indicated that Nasa-29 had a high seed yield which was significantly different from other varieties including Bisi-2 (high yield comparison and two cobs).

Corn produces stover (stems and leaves on the cob) which can be a source of forage for animal feed. Corn stover for feed in the East Lombok region, is still limited to the stems and leaves on the cob, which are cut when the corn is nearing harvest and directly given to livestock or dried for storage. Based on [24] stated that corn stover is good for cattle because it contains sufficient fiber and protein. Feed from corn stover is of better quality than that made from rice straw because the stover contains 27.8% crude fiber and 7.4% protein, while rice straw contains 28.8% crude fiber and 4.5% protein.

The weight of the stover is affected by the variety. The variety with the highest stover weight was HJ 21 (4,815 kg/ha) which was not significantly different from Bima-20 (4,685 kg/ha) and HJ 27 (4,560 kg/ha) but significantly higher from other varieties including the comparison variety Bisi-21 (3,214 kg/ha) and Bisi-2 (4,113 kg/ha). These results indicate that the varieties HJ-21, Bima-20 and HJ-27, have the potential to be developed in a maize area that is integrated with cattle.

From the total biomass produced, it was known that the HJ-21 variety had the highest weight (9,353 kg/ha) which was not significantly from HJ-27 (9,272 kg/ha) and Bima-20 (9,087 kg/ha), but was significantly higher from other varieties. Including comparisons Pioner-21 (7,533 kg/ha) and Bisi-2 (8,399 kg/ha).

Table 3. Maize biomass results from 8 hybrid superior varieties in Pringgabaya Sub District, East Lombok, West Nusa Tenggara in 2020

| Varieties   | Weight Fresh cob husk (kg/ha) | Weight Fresh cob weight (kg/ha) | Dry stover weight (kg/ha) | Total biomass weight (kg/ha) | Feeding time / 2 cows (months) |
|-------------|-------------------------------|---------------------------------|---------------------------|-----------------------------|--------------------------------|
| Bima-14     | 595 E                         | 2881 bc                         | 2518 c                    | 5,994 c                      | 5,6 c                          |
| HJ-27       | 1093 Bcd                      | 3619 a                          | 4560 a                    | 9,272 a                      | 10,1 a                         |
| Bima-20     | 1045 Cd                       | 3357 ab                         | 4685 a                    | 9,087 a                      | 10,4 a                         |
| JH-37       | 1352 A                        | 3333 ab                         | 4262 ab                    | 8,947 ab                     | 9,5 ab                         |
| HJ-21       | 1014 Cd                       | 3524 a                          | 4815 a                    | 9,353 a                      | 10,7 a                         |
| Nasa-29     | 1274 Ab                       | 2571 c                          | 4107 ab                    | 7,952 b                      | 9,1 b                          |
| Pioner-21   | 1200 Abc                      | 3119 ab                         | 3214 bc                    | 7,533 b                      | 7,1 bc                         |
| Bisi-2      | 976 D                         | 3310 ab                         | 4113 ab                    | 8,399 ab                     | 9,1 b                          |

Note: The numbers followed by the same letter in each of the same columns are not significantly different according to the BNJ/ HSD Test (Tukey) at the 95% confidence level (α = 0.05).

For the West Nusa Tenggara area, especially in the East Lombok Research location, farmers are accustomed to providing animal feed from corn biomass, especially corn stover (leaves and stems cut on the cob). Corn husks and cobs have not been utilized optimally for animal feed, because they still need a process to become animal feed.
According to [25] corn biomass consists of 50% dry matter stems, 20% leaves, 20% cobs, and 10% corn husks. If adult Bali cattle weighs 250 kg, then the need for feed from dry matter corn biomass as much as 3% of body weight is $250/100 \times 3 = 7.5 \text{ kg/head/day}$ or 225 kg/head/month.

Based on the calculation result [25], it can be converted the total biomass obtained from the eight varieties tested as shown in Table 3. From the results of the calculation in Table 3, it is known that from 1 hectare of corn plants can produce biomass/dry stover from corn variety HJ-21, as much as 4,815 kg, which were able to prepare feed for 10.7 months for 2 cows, followed by the Bima-20 variety with 4,685 kg, which was able to prepare animal feed for 10.4 months and JH-27 as much as 4,560 kg, which was able to prepare feed for 10.1 months. These three varieties were significantly different from other varieties including the comparison Pioneer-21 was only able to prepare feed for 7.1 months and Bisi-2 for 9.1 months. These results indicate that the maize varieties HJ-21, Bima-20 and JH-27 have great potential to be developed in maize production areas that have a large number of cattle. This result is supported by [26] that high yielding maize varieties that produce stay green biomass, high production early maturity (90 days), and drought tolerance are generally preferred by farmers.

4. Conclusion
Of the 8 varieties tested, there were 3 varieties of maize that had adaptability and high yield potential, namely JH-37, Nasa-29 and HJ-21. These three varieties had the advantages of long cobs, large cobs diameter and large number of seeds per row. The three varieties can be recommended to be developed in the corn production area in West Nusa Tenggara. For maize varieties that have high biomass/stove are HJ-21, Bima-20 and JH-27. The dry biomass yield of these three varieties is able to meet the needs of animal feed for more than 10 months for 2 cows. These three varieties have the opportunity to be developed in corn production areas that have a lot of cattle. Of the 8 varieties tested, there is 1 variety that has high yield potential and high biomass, namely HJ-21. This variety is feasible to be developed with an integrated system in corn production areas and cattle production areas.

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