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Yield Evaluation of Composite and Hybrid Maize Varieties under Different Number of Population on Dry Land Northern Lombok

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Abtract: *This study was aimed to determine the yield of some maize varieties grown under different planting systems on dry land of Northern Lombok, Indonesia. The experiment was designed using a completely randomized block design, with two factors, namely maize variety and number of maize population which is realized from row spacing. The maize variety factor consist of 4 composite varieties (P4IS, Gumarang, Lamuru and Sukmaraga), and one hybrid variety (NK212). The row spacing factor consist of 5 types, namely 4 types of single row spacing (20x70 cm or 71428 plant/ha, 20x60 cm or 83333 plant/ha, 15x70 cm or 95238, and 15x60 cm or 111111 plant/ha), and double rows spacing ("jarwo"), that is 2:1 (20x35)x70 cm or 107142 plant/ha. The yield of maize was determined through dry seed weight per plot. Data collected were analyzed using analysis of variance at 5% level. The difference among treatments, then further tested using Honestly Significant Difference (HSD) at the same level. The results showed that there were interactions between varieties and row spacing for the yield of maize on dry land during the rainy season. The yield of all varieties tested under double spacing ("jarwo") and the single spacing of 15x60 cm are similar, both are higher than the yield of wider single row spacing. Yield of NK212 hybrid (5.397 t/ha) is higher than the four other composite maize varieties. The "jarwo", with one plant per hole, gives a yield of 5,064 t/ha which is the same as the 15x60 cm single row soacing (5,026 t/ha), both are higher than the yield of the other three wider single row spacing.*
Keywords: *yield, number of population, dry land, and maize.*

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I. Introduction

In Indonesia, about 60% of dry land areas are used for maize cultivation areas. Therefore, technology package for growing maize on dry land is higly required for increasing maize yield in Indonesia. The package includes suitable varieties, planting systems or roe spacing, use of organic and inorganic fertilizers. Maize varieties that suitable for dry land can be expected for overcoming the decrease of maize yield (Subaedah et al. (2016). In general, the ideotypes of maize crop that tolerants to drought stress include: biomass weight before anthesis is high, stay-green, and leaves are thicker and waxy (Anonymous, 2012). Some researchers have tested several composite and hybrid varieties on dry land, and reported that the maize yiled is still far below the potential yield. In addition, hybrid varieties generally have a yield potential of more than 13 t/ha, and the composites are generally more than 7 t/ha. Sutresna, et al. (2018), found that Sukmaraga has a higher yield than Lamuru in dry land. Jaya et al (2015) tested several hybrid maize varieties on dry land of Northern Lombok with sandy texture soil, and reported, that the yield of Bisi 816 is 6.26 t/ha; Pioneer 21, 6.84 t/ha; Pertiwi-2, 5.78 t/ha, and NK 212 6.98 t/ha); the whole hybrid is still far from their potential yield. Today's commercial hybrid varieties generally have smaller leaf angles, so that increasing their yield can be done through increasing population density, and management of cropping systems.

Number of maize population can be obtained through the application of row spacing, which includes single row spacing and double row spacing ("jarwo"); both row spacing affect the number of plants per unit area. This has an effect on light utilization, weed competition and nutrient absorption (James, 2014). Double row spacing has greater adaptation in terms of absorption of water and nutrients, as well as sunlight utilization, which can finally adjust to drought stress (Monsanto Company, 2013). Baloyi (2014), found that yields at a population density of 60,000 plants/ha were 30% higher compared to that of 20,000 plants/ha under minimum tillage conditions. Gozubenli et al. (2004) reported that there was an increase in the yield capacity of maize from a population of 60,000 to 90,000 plants/ha, and a decrease in yields in higher populations with a single row spacing system. A double row spacing system is better than a single planting system. Maddonni et al. (2006) found higher yields can be obtained at narrow planting distances. The arrangement of double row spacing systems and single row planting systems on several composite and hybrid varieties has the opportunity to

provide high yields in dry land. Therefore, the aim of the study is to examine the effect of row spacing systems and varieties on the yield of maize on dry land.

II. Materials And Methods

A field experiment was conducted at Gumantar village, District of Gangga, Northern of Lombok Regency, Province of West Nusa Tenggara, Indonesia. The treatments were designed using a completely randomized block design (RCBD) with two factors. The first factor is maize varieties (V), which consist of 4 composites maize varieties, namely: P4IS (V1), Gumarang (V2), Lamuru (V3), Sukmaraga (V4), and one hybrid maize variety (NK212, V5). The second factor is number of maize populations which were obtained through the application of row spacing as follows: single row spacing with 4 different types, namely: 20x70 cm (J1), 20x60 cm (J2), 15x70 cm (J3), 15x60 cm (J4) and one "jarwo" system 2:1(20x35)x70, all of which resulted in number of maize population 71,428, 83,333, 95,238, 111,111, and 107,142 plant/ha respectively. In "jarwo" system maize was planted in double row with 20 cm distance in each row and 35 cm distance between the row, and those two maize rows were separated by a distance of 70 cm between the following two maize rows.

Soil was plowed and harrowed once to provide comfortable plots, before maize was planted. There were 3 blocks provided in this experiment, with a distance of 1 m apart, in which the 25 plots were placed. Each plot has the size of 4.2 x 2.4 m. Cattle manure was evenly incorporated in each plot a day before planting at a rate of 20 t/ha. Two maize seeds were planted in each hole of 5 cm depth, which was provided manually using wood stick, then the hole was covered with soil. Maize population in each treatment was realized through application of row spacing. At the age of 10 days, maize was spaced by leaving one plant per hole. Before planting, the maize seeds were treated with insecticide of Saromyl 35SD at a dose of 2 g/kg to prevent mildew disease. In each planting hole insecticide of Furadan 3G was applied at a rate of 20 kg/ha. Urea fertilizer was applied twice in each plot at a rate of 100 kg/ha each. First application of Urea was carried out at planting, together with application of Phonska fertilizer at rate of 300 kg/ha, and the second application was at the age of 21 days after planting. Both Urea and Phonska fertilizer were applied into the 5 cm depth of hole at a distance of about 5-7.5 cm from the planting hole. The holes for application of these fertilizers were also provided using wooden stick which operated manually.

Plants were not irrigated because the planting was conducted during rainy season. Source of irrigation water is entirely come from rainwater. Weed control and soil loosing were carried out once, that was at the age of 28 days after planting. Pest control was carried out by spraying "Alika" and "Ripus" pesticides, which was conducted before flowering or at 35 days after planting. Harvesting was carried out when the plants have shown harvesting criteria, that is when the husk and cob hair are dry and the seeds are hard, which can not be traced when pressed with nails.

The parameters observed include: plant height, number of leaves per plant, age of panicle appearance, age of cob hair appearance, harvesting age, length of cob, diameter of cob, dry weight of cobs per plant, weight of dry shelled seeds per plot, and weight of 1,000 seeds.

The data obtained were analyzed using analysis of variance based on a completely randomized block design. The different between treatments were then further tested using Honestly Significant Difference (HSD) test at 5 percent level. The analysis was carried out using Minitab Computer program version of 16.

III. Results And Discussion

Interaction between variety and planting system

Based on the analysis of variance, it is found that there is a significant interaction between maize variety and number of maize population, which was determined by row spacing, on maize yield indicated by dry weight of seeds per plot (Table 1).

Table 1. Average maize yield (dry weight of seeds, kg/ plot) based on combination of maize varieties and planting systems

Kind of varieties	J1	J2	J3	J4	J5
P4IS	3.537 ef	3.391 f	3.877 ef	5.395 abcde	4.907 abcdef
Gumarang	3.116 f	3.387 f	3.559 ef	4.792 abcdef	4.660 abcdef
Lamuru	3.985 def	4.412 bcdef	4.218 cdef	5.307 abcde	5.420 abcde
Sukmaraga	3.694 ef	4.536 abcdef	4.160 def	5.825 abdc	4.851abc def
NK212	4.038 def	4.558 abcdef	6.091 abc	6.142 ab	6.349 a

Note: *) Numbers in the columns and rows followed by the same letters are not significantly different under the HSD test at 5 percent of significantly different; J1, 20x70 cm; J2, 20x60 cm; J3, 15 x 70 cm; J4, 15 x 60 cm and J5, "jarwo" 2:1(20x35)x70 cm.

Maize yield of all varieties tested were not significantly different on the 15 x 60 cm (J4) system, and the jarwo system 2:1 (20x35)x70 cm (J5) (Table 1). However, yield of the NK212 under jarwo system tend to give higher yield than the 20x70 cm system, but it is no different to that of both spacing of 15x70 cm, and 15x60 cm.

There is a significant interaction between planting systems and varieties on maize yield. Different planting system, which are arranged under various spacing, produce different number of plants per hectare. The number of plants per hectare under "jarwo" or double spacing system of 2: 1 (20x35)x70 cm is 107,000 plants, while under single spacing system of 15x60 cm is 111,000 plants, which are much more than the other three single spacing systems (15x70, 20x60, and 20x70 cm). Difference number of plants per hectare between "jarwo" 2: 1 (20x35 cm)x70 cm and single spacing of 15x60 cm has not caused a difference in yield of all composite and hybrid varieties. This means that the edge effect of the "jarwo" system can be balanced by the addition of number of plants per hectare through the row spacing of 15x60 cm. A similar result was also found by researcher from the National Agricultural Research and Development Agency of Indonesia (2016), who reported that jarwo 2:1 (25x40)x70 cm resulted in the same yield of maize under the row spacing of 40x70 cm. Both of these planting systems (jarwo and single spacing of 15x60 cm) tend to have maize yield higher than the wider row spacing in all varieties except for Sukmaraga and NK212. This can be occurred because of less number of plants/ha of the wider single spacing systems, that is 71,428; 83,333; and 95,238 plants/ha for spacing of 20x70 cm; 20x60 cm, and 15x70 cm, respectively.

Effect of varieties of maize on growth, flowering, yield and yield components

Table 2. Average of growth parameters, flowering and harvesting age based on kind of varieties

Kind of varieties	Observed Parameters *)					
	TT	JD	UKM	UKRT	ASI	UP
P4IS	195.83 b	11.66 b	44.67 e	46.07 e	1.40	75.07 e
Gumarang	213.20 a	12.34 ab	46.00 d	47.73 d	1.73	79.07 d
Lamuru	208.54 a	12.59 a	49.80 c	51.20 c	1.40	82.67 c
Sukmaraga	205.50 ab	12.25 ab	51.73 b	52.87 b	1.13	85.73 b
NK212	206.85 ab	12.30 ab	55.40 a	56.47 a	1.07	95.07 a

Note: *) Numbers in the same column followed by the same letter are not significantly different based on the HSD test at 5 percent of significantly different; TT, plant height (cm); JD, number of leaves per plant; UKM, the age of panicle initiation (days); UKRT, age of appearance of cob hairs (days); ASI, the age difference between of cob hair appearance (days) and initiation of panicles (days) and UP, harvesting age (days).

In Table 2, it can be seen that the P4IS population has lower plant height than Gumarang and Lamuru; but it is similar to that of Sukmaraga and NK212. Number of leaves of Lamuru variety is higher than that of P4IS, but it is not different significantly to that of the three other varieties. The population of P4IS has the earliest age of panicle initiation and age of cob hair appearance, while the latest is NK212. The shortest harvesting age is occurred on P4IS variety, whiles the longest occurred in NK212.

Table 3. Average yield and yield components parameters based on kind of varieties

Kind of varieties	Observed Parameters *)				
	(BBKPL)	BTKP	PT	DT	B-1000
P4IS	4.22 bc	81.79 bc	10.24 bc	3.83 bc	190.45 b
Gumarang	3.90 c	80.51 c	9.88 c	3.71 c	165.81 c
Lamuru	4.67 b	101.37 b	11.78 b	4.07 a	229.33 a
Sukmaraga	4.48 bc	95.69 b	12.06 ab	3.92 ab	225.89 a
NK212	5.44 a	109.88 a	13.82 a	3.84 bc	224.34 a

Note: *)Numbers in the same column followed by the same letter are not significantly different based on HSD test at the level of 5 percent; BBKPL, dry weight of seeds per plot (kg); BTKP, weight of dry harvested cob per plant (g); PT, length of cob (cm); DT, diameter of cob (cm) and B-1,000, weight of 1,000 seeds (g).

It can be seen in Table 3, that NK212 variety has the highest yield and cob dry weight per plant; while the four composite varieties are not significantly different. Gumarang's cob length is statistically the same as P4IS, but it is shorter than the other three varieties (Lamuru, Sukmaraga, NK212). Cob diameter of composite variety of Gumarang is the same as P4IS and NK212, but it is smaller than Lamuru and Sukmaraga varieties. Seed quality, indicated by weight of 1,000 seeds is the lowest under Gumarang variety. The other three varieties (Lamuru, Sukmaraga, and NK212) are not different significantly.

Yield of maize varieties tested are different significantly. The hybrid variety of NK212 has higher yield than the others. This fact is consistent to that of weight of dried cobs per plant, that higher on the hybrid variety

than the four composite varieties. In addition, length of cobs also supports obtaining higher yields on NK212 (Table 3). Silva et al. (2004) found that the yield was significantly positively correlated with the number of seeds per cob and cob length. The same thing was reported by Subaedah et al. (2016), that the high yield is a result of the longer cob. In general, the potential of hybrid varieties is higher than that of composites because it utilizes the symptoms of hybrid vigor (Heterosis) (CKB Maize, 2007). Hybrid varieties have a yield potential of 50-100% even more, compared to variety of both composite, and synthetic (Kutka, 2011). NK212 has a potential yield of more than 13 tons/ha (Ministry of Agriculture, RI, 2013), while the composite varieties have potential yield of 7.6 - 8.5 tons/ha (Balitjas, 2013).

The yield of all varieties tested was lower than the yield potential of each variety. Yield of P4IS, Gumarang, Lamuru, Sukmaraga and NK212 are 4.187, 3.869, 4.633, 4.444, and 5.397 t/ha, respevtively. Under dry land condition, Jaya et al. (2015) also reported that yield of maize is far below their yield potential, which was 6.98 t/ha for NK212 during rainy season with sufficient water, but without addition of organic fertilizer. This fact may be caused by drought stress occurred during seed filling and during ripening phase without any rain water. The decrease in yields of maize experiencing drought stress differ according to the time of stress occurance. The yield reduction will be 5-10%, 10-25%, 40-50%, 30-40%, and 20-30%, if water stress occur during the beginning of the vegetative phase, panicle initiation, cob hair appearance, seed formation, and seed filling phase, respectively. Whereas if the drought stress occurs during physiological ripening phase, the decrease in yield will be highly depended on the varieties of maize (Mahanna, et al., 2012). Drought occurance during this phase can also affect age of harvesting. Among maize varieties tested, the harvesting age of ech variety vary widely. Sudika et al. (2014) found that the P4IS has harvesting age of 78 days, In addition, Balitjas (2013) reported that some varieties of maize, such as, Gumarang, Lamuru, Sukmaraga, and NK212 have harvesting age of 82, 85, 105, and 105-110 days, respectively. All of these maize varieties have a faster harvesting age compare to that mentioned on the varieties description (Table 2.) This may occur due to the occurance of drought stress which was occurred during the grain filling phase, and ripening periods which end up to faster harvesting age and lower yields.

Effect of maize population number on growth, flowering, yield and yield components

The yield components, such as dry weight of cob per plant, length of cob, diameter of cob, dry weight of seed per plant and weight of 1,000 seeds under different population number or row spacing treatments are not significantly different. The maize yield under "jarwo" system (107,142 plants/ha) is not significantly different to that of the single spacing system of 15x60 cm (111,111 plants/ha), and 20x60 cm (83,333 plants/ha), but they are higher than single spacing of 15x70 cm (95,238 plants/ha), and 20x70 cm (71,428 plants/ha).

Table 4. Average growth rates, and flowering and harvesting age based on factor of plantingsystems

Planting system/Row spacing	Observed Parameters *)					
	TT	JD	UKM	UKRT	ASI	UP
20 x 70 cm	195.33 b	11.81 b	49.47 ab	51.13 ab	1.67	83.87
15 x 70 cm	210.57 a	12.53 ab	49.27 b	50.27 b	1.00	83.60
20 x 60 cm	207.70 a	12.18 ab	49.13 b	50.60 b	1.47	83.40
15 x 60 cm	211.48 a	12.62 a	49.40 ab	50.67 b	1.27	83.40
(20x35)x70 cm	204.83 ab	12.01 ab	50.33 a	51.73 a	1.40	83.40

Note: *) Numbers in the same column followed by the same letter are not significantly different based on HSD test at the level of 5 percent; TT, plant height (cm); JD, number of leaves per plant; UKM, the age of panicle initiation (days); UKRT, age of cob hair appearance (days); ASI (Anthesis Silking Interval), the difference between age of cob hair appearance and age of panicles initiation (days) and UP, harvesting age (days).

Maize plant grown under row spacing of 20x70 cm system has shorter plant height than the other single spacing systems, but are similar to that of Jarwo system. Number of leaves per plant is not statistically different among cropping systems, except the plant height under row spacing of 20x70 cm is shorter than the row spacing of 15x60 cm. The age of panicle initiation under the jarwo planting system is statistically the same as the 20x70 cm and 15x60 cm. Similarly, the age of cob hair appearance under jarwo system is not different statistically to that of the spacing of 20x70 cm. All of the two planting systems (tile and jarwo) had similar effect on both Anthesis-Silking Interval (ASI) and the harvesting age.

Table 5. Average yield and yield components based on factor of planting systems

Planting System/Row Spacing	Observed Parameters *)				
	(BBKPL)	BTKP	PT	DT	B-1000
20 x 70 cm	3.674 d	98.68	11.40	3.94	214.69
15 x 70 cm	4.057 cd	94.57	11.62	3.87	208.66
20 x 60 cm	4.599 bc	93.13	11.20	3.89	201.05
15 x 60 cm	5.067 a	94.66	11.43	3.85	205.78
(20x35)x70 cm	5.105 ab	92.02	12.47	3.82	205.30

Note: *) Numbers in the same column followed by the same letter are not significantly different based on the HSD test at 5 percent level; BBKPL, dry shelled seed weight per plot (kg); BTKP, harvested dry cob weight per plant (g); PT, cob length (cm); DT, cob diameter (cm); and B-1000, weight of 1,000 seeds (g).

The yield components, such as dry weight of cob per plant, length of cob, diameter of cob, dry weight of shelled seed per plant and weight of 1,000 seeds under different spacing treatments are not significantly different. The maize yield under jarwo system is not significantly different to that of the single spacing system of 15x60 cm, and 20x60 cm, but they are higher than single spacing of 15x70 cm, and 20x70 cm.

Number of maize populations per hectares has effect on significant different on yield of maize. Population number of 107,142 plant/ha that provided under double row spacing or "jarwo" (2: 1 (20 x 35 cm) x 70 cm) one plant per hole, has the same yield as the population of 111,111 plants/ha or 15 x 60 cm row spacing, and population of 83,333 plants/ha or 20 x 60 cm row spacing, 1 plant per hole. However, under double spacing of "jarwo" has higher yield than the wider tiled planting system, which is 20 x 70 cm and 15 x 70 cm, 1 plant per hole. The yield component, including the weight of the dry cob per plant, the length of the cob, diameter of cob, and weight of 1,000 seeds were not different significantly based on number of population (Table 5). This fact indicated that different in yield is due to different population densities, the narrower the spacing or the higher the population, will end up with the higher the mize yield. Maddonni et al. (2006) also found that higher yields would be obtained at narrow planting distances. This can be becaused by the side effect of crop on a double row spacing system. Double row spacing system has greater potential in terms of absorption of water, nutrients and sunlight and finaly it will be able to cope with drought stress (Monsanto Company, 2013). James (2014) stated that the double row planting systems is better than the single row systems with regard to light intercepts, weed competition and nutrient absorption. Baloyi (2014) found that maize yield under population density of 60,000 plants/ha is higher (approximately 30%) compared to 20,000 plants/ha with minimum tillage. Gozubenli et al. (2004) reported that there was an increase in the yield of maize under population of 60,000 to 90,000 plants/ha and decrease in yield under higher populations with a single row planting system. Double row spacing is better than the single row planting system.

IV. Conclusions And Recommendation

Based on the results and discussion above, it can be concluded some points, as follows:

1. There is a significant interaction between maize varieties and number of maize population, obtained by different row spacing, on yield of maize in dry land during the rainy season. The yield of all varieties tested under double row spacing ("jarwo") and single row spacing of 15x60 cm are not different, and both have hinger yield than the wider row spacing.
2. Yield of NK212 hybrid variety is 5.4 t/ha, which is higher than the four composite maize varieties tested.
3. The "jarwo" system 2:1 (20x35)x70 cm, one plant per hole, gives a yield of 5.1 t/ha, which is similar to that of the single row spacing of 15 x 60 cm, one plant per hole with the yield of 5.0 t/ha.
4. NK212 hybrid maize variety with "jarwo" 2:1 (20x35)x70 cm system and spacing of 15x60 cm, one plant per hole, is highly recommended to be applied on dry land.

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