

Advanced yield potential test on synthetic genotype of maize tolerant to drought and low nitrogen

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Abstract. Increased productivity of maize with intensification can be achieved through the release of tolerant varieties to drought and or low nitrogen conditions while supporting extensification to marginal land. During 2013-2015, previous studies had obtained three candidates of maize new superior varieties (NSV) tolerant to drought and low nitrogen (N) (Syn2-4, Syn2-8, and Syn2-16); and six varieties tolerant to drought or low N (Syn2-1, Syn2-2, Syn2-4, Syn2-8, Syn2-15, and Syn2-16). The potential yield of these genotypes under drought or low N conditions was 6.5 t Ha⁻¹. To examine the potential yield of these 6 genotypes, advanced test was conducted using three maize varieties (Lamuru, Sukmaraga and Bisma) as comparison. The results show that the genotypes of synthetic maize which gave the highest and better yield potential compared to the three comparators varieties of Lamuru, Sukmaraga and Bisma were Syn2-4 (8.13 t Ha⁻¹), Syn2-15 (8.21 t Ha⁻¹), and Syn2-16 (9.23 t Ha⁻¹). While the other three genotypes only gave higher yields than the varieties of Bisma and Lamuru with potential yield of Syn2-1, Syn2-2 and Syn2-8 were 6.74, 7.06 and 7.78 t Ha⁻¹, respectively. Increased production was more dominant due to the difference in the number of cob at harvest and weight of 1000 seeds.

1. Introduction

Corn demand constantly increases every year with population and with the progress of food processing technology industries and poultry farms use corn as feeds. During the period of 2011-2015 the average export volume was 23.96 thousand tons, while import volume was much higher at 2.50 million tons. Negative balance between these volumes are indicated by much smaller export compare to import with deficit of averagely 2 million tons more in import volumes from year 2011 to 2015 [1]. This shows that the dependence of imported maize will increase in recent years. Indonesian corn production in 2011-2015 period has been fluctuated. The lowest production was 17.64 million tons in 2011 and increased in 2014 by 19.0 million tons. An increase in production growth rate of 3.18% in 2015 resulted in production reached 19.61 million tons with an average productivity of 5.18 t Ha⁻¹ [2]. To fulfill the requirement, use of synthetic corn variety which is tolerant to drought stress and low N fertilization with high productivity and acceptable to farmer is necessary. The synthetic corn variety can support a larger corn crop and involves less-capitalized farmers, thus contributing to increased production toward sustainable self-sufficiency in maize.

Selection activities require information regarding the morphology and physiology of corn crops tolerant to low drought and N stress, so that the selection process can be carried out efficiently and effectively. The reported morphological and physiological characteristics associated with tolerant



properties of maize plant to drought stress include deep root system [3, 4, 5, 6, 7, 8], water use efficiency, rate of water loss through transpiration, stomatal density [6], and ability to protect chloroplast apparatus and senescence [9, 10, 11], accumulation of proline [12], leaf rolling sensitivity [13], interval timing of male and female flowers (anthesis interval silking or ASI) and male flower size [4]. Based on a series of studies that have been conducted [14, 15] it was obtained three candidates of superior varieties of corn tolerant to drought and low nitrogen (Syn2-4, Syn2-8, and Syn2-16); and six candidates tolerant to drought or low N (Syn2-1, Syn2-2, Syn2-4, Syn2-8, Syn2-15, and Syn2-16). The potential yield of these candidates was 8 t Ha⁻¹ under optimum conditions and 6.5 t Ha⁻¹ in drought or low N conditions. A further study needs to be undertaken to study the potential yield of the 6 synthetic maize genotypes compared with three varieties (Lamuru, Sukmaraga and Bisma).

2. Methodology

The study was conducted in Maros Regency, South Sulawesi from June to September 2017 as experimental study set in a randomized block design with three replications. The treatment consists of six genotypes of synthetic corn, namely Syn 2-3, Syn 2-4, Syn 2-5, Syn 2-6, Syn 2-7, Syn 2-8, and 3 comparison varieties i.e. Bisma, Lamuru, and Sukmaraga. Maize were planted in 5 m x 3 m plot using plant spacing of 70 cm x 20 cm. Plots were applied with Urea, SP36 and KCl 300 fertilizers with dosages of 300, 200 and 100 kg Ha⁻¹, respectively. Urea and KCl fertilizers were given twice at the age of 7 and 35 days after planting (DAP), while SP36 was applied at 7 DAP. 10% of the total population were taken as samples with parameters observed were leaf angle, chlorophyll content using Chlorophyll Meter (calculated according to [16], weights of cob, yield, number of harvest crop, number of cob harvest, cob harvest weight and productivity at moisture content of 14% using Grain Moisture Tester PM-410. Data was analysed using analysis of variance followed by Least Significance Difference (LSD) test at $p < 0.05$. To determine the relation between growth characters and production, regression and correlation analysis were conducted while heritability in the broad sense using the formula of Syukur *et al.* [17]:

$$KKG = \frac{\sqrt{\sigma^2 g}}{\bar{x}} \times 100\%$$

Heritability values are grouped according to Bahar and Zen [18] *i.e.* low (<0.2), medium (0.2-0.5) and high (>0.5).

3. Results and Discussion

Table 1 shows that the leaf angle of genotype 3 (Syn 2-5), 5 (Syn 2-7) and 6 (Syn 2-8) showed the highest leaf angle and differ significantly ($p < 0.05$) with control genotypes of Lamuru and Sukmaraga (g8 and g9). High angle of the leaf shows upright canopies that are parallel to the sunlight so that the sunlight received by the leaves becomes the optimum compared to the low leaf angle that indicates overlapping leaves results in lower light reception. This is in accordance with Kartahadimaja and Eka [20] stating that plants with narrow leaves and leaf shrubs smaller than 60° will receive less light when compared to more than 60° leaf angle. According Sumajow *et al.* [21], an upright leaf angle is a character favoured by corn farmers. The use of sunlight will be more effective and efficient, result in better photosynthesis activities. Narrow leaf corner character with upright leaf growth type can also increase plant population in unit of plantation area, this is because spacing can be used more closely by not disturbing penetration of light reaching to body part of the plant.

Higher radiation received by the leaves will trigger the optimum process of photosynthesis to produce assimilates that can be distributed to the generative organ to support the high production of corn crops. The weight of cob is influenced by the distribution of assimilates from the photosynthesis process and the availability of water and nutrients available in the soil, the narrow spacing apart from the non-optimum sunlight by the leaves can also detain root development due to nutrient competition causing lack of nutrients for corn so the most prominent impact in this case is the leaves due to lack of raw materials to make leaf chlorophyll so that with the lack of chlorophyll content in the leaves will affect

the amount of assimilates produced to be distributed for the formation of seeds and seed filling. This is in line with the opinion of Sumajow *et al.* [21] which states that drought and nutrient deficiency greatly affect the growth and development of cobs, and will even decrease the number of seeds in one cob because of the shrinking of the cob, which consequently decreases the yield.

Table 1. Average leaf angle ($^{\circ}$), chlorophyll content (mg cm^{-2}), cob weight (g) and rendement (%) in some synthetic maize genotypes.

Genotype	Leaf Angle ($^{\circ}$)	Chlorophyll Content (mg cm^{-2})	Cob Weight (g)	Rendemen (%)
g1 (<i>Syn 2-3</i>)	57.87 ^{abc}	0.3061	200.20 ^{bc}	77.23 ^a
g2 (<i>Syn 2-4</i>)	59.93 ^{ab}	0.3048	216.60 ^{ab}	76.20 ^{abc}
g3 (<i>Syn 2-5</i>)	60.13 ^{ab}	0.3060	217.93 ^{ab}	73.84 ^d
g4 (<i>Syn 2-6</i>)	60.20 ^{ab}	0.3086	199.00 ^{bc}	77.06 ^{ab}
g5 (<i>Syn 2-7</i>)	60.00 ^{ab}	0.3062	199.47 ^{bc}	76.37 ^{abc}
g6 (<i>Syn 2-8</i>)	62.67 ^a	0.3044	217.27 ^{ab}	77.01 ^{abc}
g7 (Bisma)	59.27 ^{ab}	0.3055	185.80 ^c	75.02 ^{cd}
g8 (Lamuru)	55.87 ^{bc}	0.3054	214.60 ^{ab}	73.95 ^d
g9 (Sukmaraga)	53.67 ^c	0.3048	234.07 ^a	75.11 ^{bcd}
LSD 0.05	4.84	ns	19.99	2.02

Values followed by same letter in the same column are not significantly different ($p < 0.05$).

Table 2. Average number of harvested crops (plant plot^{-1}), number of cobs at harvest (cob plot^{-1}), cob weight at harvest (kg plot^{-1}) and productivity (ton Ha^{-1}) of some synthetic maize genotypes.

Genotype	Number of harvested crops (plant plot^{-1})	Number of cobs at harvest (cob plot^{-1})	Cob weight at harvest (kg plot^{-1})	Productivity (ton Ha^{-1})
g1 (<i>Syn 2-3</i>)	67.67 ^{cd}	76.33 ^{bc}	13.86 ^c	6.74 ^{bc}
g2 (<i>Syn 2-4</i>)	69.00 ^{cd}	78.00 ^{abc}	15.16 ^b	7.06 ^{bc}
g3 (<i>Syn 2-5</i>)	70.00 ^{bcd}	88.00 ^{ab}	18.46 ^{ab}	8.13 ^{ab}
g4 (<i>Syn 2-6</i>)	87.00 ^a	93.33 ^{ab}	16.35 ^{abcd}	7.78 ^{ab}
g5 (<i>Syn 2-7</i>)	85.67 ^{ab}	93.33 ^{ab}	17.85 ^{abc}	8.21 ^{ab}
g6 (<i>Syn 2-8</i>)	80.33 ^{abc}	96.33 ^a	20.22 ^a	9.23 ^a
g7 (Bisma)	81.33 ^{abc}	88.33 ^{ab}	12.36 ^d	5.63 ^c
g8 (Lamuru)	62.00 ^d	62.00 ^c	12.71 ^d	5.79 ^c
g9 (Sukmaraga)	77.00 ^{abcd}	81.67 ^{ab}	17.78 ^{abc}	7.87 ^{ab}
LSD 0.05	16.14	19.09	4.05	1.67

Values followed by same letter in the same column are not significantly different ($p < 0.05$).

Table 2 shows the genotypes of *Syn 2-5*, *Syn 2-7* and *Syn 2-8* gave the highest potential on the number of harvest cobs, the weight of the cobs and the productivity. This suggests that these genotypes showed good potential to be developed when compared to the comparative genotypes. According to Syukur *et al.* [17], the quantitative character of the plant is affected by a number of genes, each having a small contribution to its phenotypic appearance. There is an interaction between genes and the environment concerning factors in plant cells.

Genotypes *Syn 2-5*, *Syn 2-7* and *Syn 2-8* which are the origin of the count of elders who have extensive genetic viability with the Balance Composite method produce a genotype superior to the elder. This is in agreement with Budiarti [22] which states that the development of improved varieties is geared

towards obtaining high yield potential, resistant or tolerant to biotic and abiotic stress, high yield quality, according to consumer tastes and market demand. This is in line with the objectives of plant breeding in Indonesia prioritized to increase genetic yield potential, shorten plant life, improve plant resistance to important diseases, such as rust, leaf blight, virus and nematodes, improve resistance to important pests, such as bean flies and pest sucking pests, improving crop tolerance to physical environmental stresses, such as low pH, dryness, shade and improved seed quality especially colour, size and quality of saving [23]. Longer selection is done in the hope of higher potential than previous elders.

Table 3 shows that characters having wide genetic diversity coefficients and high heritability values were harvest cob weight and productivity. This indicates a potential character enhancement that developed in the next generation. High heritability values show a more significant genetic effect when compared with the environment. This is in agreement with Martono [24] which suggests that extensive genetic diversity suggests a more dominant genetic influence than environmental influences. In addition, Hikam [25] states that the greater the genetic diversity present in a crop population the easier it is for breeders to select the best desired genotypes.

Table 3. Genetic diversity coefficient analysis and heritability values.

No	Character	Genetic Diversity Coefficient		Heritability	
1	Leaf angle	3.63	Narrow	63.65	High
2	Chlorophyll content	0.18	Wide	20.11	Medium
3	Cob weight	6.12	Narrow	78.70	High
4	Rendemen	2.25	Wide	48.66	Medium
5	Number of harvested plants	9.11	Narrow	62.06	High
6	Number of cob at harvest	10.82	Narrow	65.67	High
7	Weight of cob at harvest	14.80	Wide	75.65	High
8	Productivity	14.10	Wide	77.78	High

4. Conclusion

Genotypes Syn 2-8, Syn 2-7, and Syn 2-5 are genotypes that have better potency with productivity for each genotypes were 9.23, 8.21 and 7.78 ton Ha⁻¹, respectively. Characters that have wide genetic diversity coefficients and high heritability are harvest cob weight and productivity. Characters show wide genetic diversity coefficient were chlorophyll content, yield, harvest cob weight and productivity.

References

- [1] Indonesian Bureau of Statistics (IBS) 2015 *Data Produksi Tanaman Pangan dan Hortikultura*. (Jakarta:Pusat Data Statistik Pertanian)
- [2] Indonesian Bureau of Statistics (IBS) 2016 *Data Produksi Tanaman Pangan dan Hortikultura*. (Jakarta:Pusat Data Statistik Pertanian)
- [3] Grzesiak S, Hura T, Grzesiak M T and Pienkowski S 1999 The impact of limited soil moisture and waterlogging stress conditions on morphological and anatomical root traits in maize (*Zea mays* L.) hybrids of different drought tolerance *Acta Physiol. Plant.* **21** (3) 305-315
- [4] Bänziger M, Edmeades G O, Beck D and Bellon M 2000 *Breeding for Drought and Nitrogen Stress Tolerance in Maize From Theory to Practice* (Mexico: CIMMYT)
- [5] Bohn M, Novais J, Fonseca R, Tuberosa R and Grift T E 2006 Genetic evaluation of root complexity in maize *Acta Agro. Hungarica* **54** (3) 1-13
- [6] Blum A 2005 Drought resistance, water-use efficiency, and yield potential: are they compatible, dissonant, or mutually exclusive? *Aus. Agri. Res.* **56** 1159–1168
- [7] Vadez V, Krishnamurthy L, Kashiwagi J, Kholova J, Devi J M and Sharma K K 2007 Exploiting the functionality of root systems for dry, saline, and nutrient deficient environments in a

- changing climate *J. of SAT Agr. Res.* **4** 1-61
- [8] Trachsel S 2009 *Genetic analysis of root morphology and growth of tropical maize and their role in tolerance to desiccation, aluminum toxicity and high temperature* (Switzerland: ETH Zurich) p 113
 - [9] Prochazkova D, Sairam R K, Srivasta G C and Singh D V 2001 Oxidative stress and antioxidant activity as the basis of senescence in maize leaves *Plant Sci.* **161** 765-771
 - [10] Mittler R 2002 Oxidative stress, antioxidants and stress tolerance *Trends Plant Sci.* **50** 405-410
 - [11] Messmer R, Fracheboud Y, Bänziger M, Stamp P and Ribaut J M 2011 Drought stress and tropical maize: QTLs for leaf greenness, plant senescence, and root capacitance *Field Crops Res.* **124** 93-103
 - [12] Moussa H R and Abdel-Aziz S M 2008 Comparative response of drought tolerant and drought sensitive maize genotypes to water stress *Aus. J. Crop Sci.* **1** (1) 31-36
 - [13] Edmeades G O, Bolan~os J, Chapman S C, Lafitte H R and Banziger M 1999 Selection improves drought tolerance in tropical maize populations: I. Gains in biomass, grain yield, and harvest index *Crop Sci.* **39** 1306-1315
 - [14] Efendi R, Sunarti S, Musa Y, Farid M, Rahim D and Azrai M 2015 Selection of homozygosity and genetic diversity of maize inbred using simple sequence repeats (SSRs) marker *Int. J of Curr. Res. in Biosci. and Plant Bio.* **2** (3) 19-28
 - [15] Efend R, Musa Y, Farid M, Rahim D, Azrai M and Pabendon M 2015 Seleksi jagung inbrida dengan marka molekuler dan toleransinya terhadap kekeringan dan nitrogen rendah. *J. Pen. Pert. Tan. Pangan* **34** 43-54
 - [16] Silla F, Gonzalez-Gil A, Gonzalez-Molina M E, Mediavilla S and Escudero A 2010 *Estimation of Chlorophyll Using a Portable Chlorophyll Meter (For Sci.)* (Spain: Universidad de Salamanca) p 67-108
 - [17] Syukur M, Sujiprihati S and Rahmi Y 2012 *Teknik Pemuliaan Tanaman* (Bogor: Penebar Swadaya)
 - [18] Bahar H and Zen S 1993 Parameter genetik pertumbuhan tanaman, hasil dan komponen hasil jagung *Zuriat* **4** 4-7
 - [19] Atma W A, Hana D R, Adi O R H, Meddy R and Agung K 2015 Penampilan karakter agronomi 16 genotip kedelai (*Glycine max* L. Merrill) pada pertanaman tumpangsari dengan jagung (*Zea mays* L.) pola 3:1 *J. Agro* **2** (2)
 - [20] Kartahadimaja J and Eka E S 2013 Penampilan karakter fenotipik 15 galur inbred jagung selfing ke-14 (S-14) rakitan polinela *J. Agrotrop.* **18** (2) 46-51
 - [21] Sumajow A Y M, Johannes E X R and Selvie T 2016 Pengaruh pemangkasan daun bagian bawah terhadap produksi jagung manis (*Zea mays* var. *saccharata* Sturt) *J. ASE* **12** (1A)
 - [22] Budiarti S G 2001 Skrining plasma nutfah jagung terhadap kekeringan *Bul. Agron.* **29** (1) 19-22
 - [23] Marame F L, Desalegne, Harjit-Singh, Fininsa C and Sigvald R 2008 Genetic components and heritability of yield and yield related traits in hot pepper *Res. J. Agric. & Biol. Sci.* **4** (6) 803-809
 - [24] Martono B 2009 Keragaman Genetik, Heritabilitas dan korelasi antar karakter kuantitatif nilam (*Pogostemon* sp.) hasil fusi protoplas *J. Littri* **15** (1) 9-15
 - [25] Hikam S 2010 *Teknik Perancangan dan Analisis Pemuliaan Tanaman Bahan Kuliah TPAPT* (Bandar Lampung: Fakultas Pertanian. Universitas Lampung)