

Character assessment of hybrid maize candidates tolerant to drought stress

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Abstract. Preliminary tests were carried out to determine the characteristics of candidate hybrid maize varieties compared to other varieties. This research aimed to evaluate the characteristics of 46 candidate maize hybrids. The study was conducted in Kamal sub-district, Bangkalan district, from March to June 2024. The plant material used in this research was 49 maize genotypes (46 hybrid maize candidates and three maize varieties as comparison). This research uses a simple lattice design (7x7x2). The observation parameters in this research are plant height, ear length, days to 50% tasselling, days to 50% silking, harvest age, number of kernel rows, ear diameter, ear length, kernel length, kernel width, kernel thickness, 1000-kernel weight, and production per hectare. Data were analysed using the F-test; if the treatment had a significant effect, a further test was carried out using the HSD test ($\alpha=5\%$). The results showed that several plant characters from the 49 genotypes tested had significant differences except for plant height and ear height characteristics. Characteristics of production per hectare were significantly and positively correlated with kernel length. G1, G2, G7, G16, G31, G32, G35, G39, and G46 are selected hybrid maize candidates for further testing in variety release because they have early and medium harvest age and high production per hectare (above 5,000 kg per hectare).

1 Introduction

Sub optimal land use is a strategic step in increasing food production in Indonesia. The suboptimal land in Indonesia is $\pm 80\%$ (144.5 million hectares), consisting of dry land with a wet climate of 133.70 million hectares and dry land with a dry climate of 10.8 million hectares [1]. Dry land with a dry climate consists of dry land with a dry climate in the lowlands and highlands. Dry land with a dry lowland climate of 9.32 million hectares is spread across Nusa Tenggara, Eastern Sulawesi, Eastern Java, and Eastern Papua. Furthermore, dry land with a dry highland climate is 1.48 million hectares spread across Nusa Tenggara, eastern Java, and Sulawesi [2]. Land use in dry climates in Indonesia is still not optimal, so plant productivity is very low. One of the maize-producing areas in Indonesia is the Madura Islands, which has a maize-planting area of approximately 300,000 hectares. However, productivity at the farmer level is still low at an average of 2,157 tons per hectare [3]. This low productivity is caused by the maize planting area in the Madura Islands being dominated by suboptimal land (dry land with a dry climate) [4].

One strategy to overcome the problem of low maize production in dry land with a dry climate in Madura is to develop hybrid varieties with high production characteristics and tolerance to drought stress. The development of maize varieties with high production characteristics that are tolerant to drought stress can be done using maize with tolerance to drought stress. In

2022, selection was carried out on 17 potential maize lines for drought stress using molecular and morphological markers to produce 4 maize lines with high production characteristics and tolerant to drought stress [5]. The results of the selection of lines against drought stress and several potential lines were used as parents for assembling hybrid maize varieties against drought stress. The method used to assemble hybrid maize varieties is diallel and line x tester crosses. Plant breeders often use diallel crossing to produce hybrid maize varieties [6] [7] [6] [8] [9]. Line x tester crosses are often used to see the combining ability of a genotype and have a simpler method than diallel crosses [10] [11] [12] [13] [14]

Several stages that must be carried out in releasing a variety are carrying out a Preliminary Test (one testing location), Advanced Testing (three testing locations), and Multi-location Testing (eight testing locations over two seasons). In this research, a preliminary test was carried out, resulting in a hybrid maize candidate with high production and was tolerant to drought stress. Selected hybrid maize candidates with high production characteristics and tolerance to drought stress produced in the Preliminary Test will be used as research material in the preliminary and Multilocation tests. The results of the multi-location test are used as a basis for the Ministry of Agriculture to issue a certificate for releasing high-yielding hybrid maize varieties that are tolerant of drought stress. This study aims to test the characteristics of 46 candidate maize hybrids.

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2 Research methods

2.1 Genetic materials and experimental site

The research used 49 genotypes, consisting of 46 candidate maize hybrids and three comparisons (Pioneer, Jakaring, Bisi) (Table 1). It was conducted from March to June 2024 in Bangkalan Regency, Madura, Indonesia. The research location is located at latitude: 7°09'14.8" S, longitude: 112°44'01.6" E, altitude: 5 m, average annual rainfall: 269 mm, temperature: 28- 32°C, Grumusol soil type, pH: 7.1.

Table 1. 46 maize genotypes resistant to drought stress and 3 comparison varieties.

No	Genotype	Crossing	No	Genotype	Crossing
1	G1	G174 x G161	26	G26	G258 x G201
2	G2	G176 X161	27	G27	G259 x G201
3	G3	G99 x G161	28	G28	G261 x G201
4	G4	G173 x G88	29	G29	G262 x G201
5	G5	G33 x G176	30	G30	G301 x G201
6	G6	G35 x G176	31	G31	G351 x G201
7	G7	G85 x G176	32	G32	G352 x G201
8	G8	G176 x G171	33	G33	G401 x G201
9	G9	G175 x G01	34	G34	G402 x G201
10	G10	G125 x G175	35	G35	G451 x G501
11	G11	G162 x G29	36	G36	G452 x G501
12	G12	G97 x G163	37	G37	G454 x G501
13	G13	G168 x G32	38	G38	G455 x G501
14	G14	G124 x G171	39	G39	G456 x G501
15	G15	G164 x G31	40	G40	G457 x G501
16	G16	G63 x G75	41	G41	G458 x G501
17	G17	G25 x G63	42	G42	G459 x G501
18	G18	G168 x G30	43	G43	G460 x G501
19	G19	G41 x G169	44	G44	G461 x G501
20	G20	G251 x G201	45	G45	G462 x G501
21	G21	G253 x G201	46	G46	G463 x G501
22	G22	G254 x G201	47	Check (47)	BISI-2 variety
23	G23	G255 x G201	48	Check (48)	Jakaring variety
24	G24	G256 x G201	49	Check (49)	Pioneer variety
25	G25	G257 x G201			

2.2 Experimental design, management and data collected

This research uses a simple lattice design (7x7x2). The treatments consisted of 49 genotypes of maize plants (46 hybrid maize candidates and three comparison varieties). The observation parameters in this research are plant height, ear length, days to 50% tasselling, days to 50% silking, harvest age, number of kernel rows, ear diameter, ear length, kernel length, kernel width, kernel thickness, 1000-kernel weight, and production per hectare. Each genotype was planted in a plot of 1 m × 4 m with a spacing of 70 cm × 20 cm. Each square contained 40 plants. Fertilization was carried out in three stages: (1) at seven days after planting (DAP), i.e., 100 kg ha⁻¹ urea, 200 kg ha⁻¹ SP-36, and 50 kg ha⁻¹ KCl; (2) at 25 DAP, i.e., 100 kg ha⁻¹ urea and 50 kg ha⁻¹ KCl; and (3) at 40 DAP (100 kg ha⁻¹ urea). Drought stress in this study followed the CIMMYT method [15]; namely, drought stress takes place when the plants are 40 days after planting (DAP) until harvest but provides irrigation with field capacity from 0 DAP to 40 DAT with intervals of once every ten days.

2.3 Data Analysis

Quantitative character data was analyzed using the F test. If there is a significant effect, continue with the Honestly Significant Difference (HSD) Test (p<0.05) using STAR software. Pearson correlation coefficient analysis is calculated based on the formula [16].

3 Result and discussion

3.1 Plant height, ear height, days to 50% tasselling, days to 50% silking, harvest age

Observations of plant height and ear height were carried out when the plants entered the generative phase, which was marked by the appearance of tassels (male flowers) on maize plants (Table 2). Hybrid maize candidates (G1 to G46) have plant heights ranging from 182.00 cm (G38) to 260.67 cm (G36). There were no significant differences between all the genotypes tested in plant height. Furthermore, regarding ear height, all genotypes tested had no significant differences. However, G29 has the lowest ear height (94.78 cm), and G36 has the highest ear height (132.72 cm).

The characteristics of days to 50% tasselling, days to 50% silking, and harvest age significantly differed between the genotypes tested. On the days to 50% tasselling character, the hybrid maize candidate that has the shortest days to 50% tasselling is G4 (43.50 days), and the highest days to 50% tasselling are G12, G32, and G34 (54 days). On the days to 50% silking, the hybrid maize candidate with the shortest days to 50% silking is G6 (46.50 days) and the highest female flowering ages are G23, G32, and G34 (53.00 days). Furthermore, the genotype with the shortest harvest age is G4 (87 days), and the longest is G12, G32, and G34 (100.50 days).

3.2 Number of kernel rows, ear diameter, and ear length

The number of kernel rows, ear diameter, and ear length differed significantly from all genotypes tested (Tables 2 and 3). Hybrid maize candidates have the number of kernel rows ranging from 11 to 19 rows of seeds. G12 has the lowest number of kernel rows (19 rows), while G6 and G7 have the highest number of kernel rows (19

rows). On the ear diameter, hybrid maize candidates have ear diameters ranging from 3.25 cm to 4.40 cm. G3 has the lowest ear diameter (3.25 cm), while G7 has the highest ear diameter (4.40 cm). Furthermore, hybrid maize candidates have ear lengths ranging from 10.80 cm to 18.35 cm. G38 has the shortest ear length (10.80 cm), while G2 and G13 have the longest ear length (18.35 cm).

Table 2. Average of plant height, Days to 50% tasselling, Days to 50% silking, Harvest age, number of kernel rows, and kernel diameter in 49 maize plant genotypes.

Genotype	Characteristic						
	PH (cm)	EH (cm)	D50%T (days)	D50%S (days)	HA (days)	NKR	ED (cm)
G1	243.17	118.58	45.50 d-h	51.00 a-d	91.50 f-k	16 a-d	4.20 bcd
G2	209.00	101.00	45.50 d-h	47.00 de	91.50 f-k	18 ab	4.00 c-h
G3	238.00	112.00	48.00 a-e	52.50 ab	96.00 a-f	16 a-d	3.25 m
G4	231.17	113.08	43.50 h	49.00 a-e	87.00 k	18 ab	3.90 d-i
G5	207.17	104.58	44.50 fgh	48.50 b-e	88.50 ijk	17 abc	4.00 c-h
G6	226.00	110.50	44.00 gh	46.50 e	87.50 jk	19 a	3.65 f-m
G7	232.33	112.67	47.00 a-g	50.00 a-e	94.50 b-h	19 a	4.40 abc
G8	211.00	106.00	49.00 abc	51.00 a-d	98.50 a-d	18 ab	3.35 klm
G9	252.07	122.00	45.50 d-h	48.00 cde	91.50 f-k	15 a-e	3.45 i-m
G10	209.17	105.59	48.00 a-e	51.00 a-d	96.50 a-f	15 a-e	3.90 d-i
G11	238.83	120.53	46.50 b-h	48.50 b-e	94.00 c-h	14 b-e	4.20 bcd
G12	232.50	115.04	50.00 a	51.00 a-d	100.50 a	13 cde	3.40 j-m
G13	251.17	127.70	49.00 abc	52.00 abc	99.00 abc	14 b-e	3.75 d-l
G14	207.33	104.89	49.00 a-c	52.50 ab	99.00 abc	13 cde	3.60 g-m
G15	240.50	121.58	48.00 a-e	52.00 abc	97.00 a-e	14 b-e	4.05 c-g
G16	205.67	103.34	45.00 e-h	48.50 b-e	90.00 h-k	14 b-e	3.85 d-j
G17	229.33	115.72	48.00 a-e	51.50 abc	97.00 a-e	15 a-e	4.10 c-f
G18	244.50	122.63	47.00 a-g	51.00 a-d	94.00 c-h	17 abc	4.05 c-g
G19	235.17	120.27	45.00 e-h	47.00 de	90.50 g-k	15 a-e	4.10 c-f
G20	211.17	107.80	48.00 a-e	50.00 a-e	96.50 a-f	14 b-e	4.15 b-e
G21	236.50	118.25	47.00 a-g	51.50 abc	93.50 d-i	13 cde	3.80 d-k
G22	224.17	114.11	46.00 c-h	49.00 a-e	92.50 e-j	12 de	4.05 c-g
G23	225.50	111.76	48.00 a-e	53.00 a	96.50 a-f	13 cde	3.80 d-k
G24	233.83	115.42	48.00 a-e	51.50 abc	97.00 a-e	15 a-e	3.85 d-j
G25	191.33	96.78	48.50 a-d	53.00 a	97.50 a-e	15 a-e	3.90 d-i
G26	206.23	105.11	45.00 e-h	47.00 de	90.50 g-k	16 a-d	3.85 d-j
G27	214.33	106.78	47.00 a-g	50.00 a-e	94.50 b-h	14 b-e	3.80 d-k
G28	225.83	113.38	48.00 a-e	52.00 abc	96.50 a-f	15 a-e	4.05 c-g
G29	190.33	94.78	47.50 a-f	49.50 a-e	95.50 a-g	14 b-e	4.05 c-g
G30	205.67	103.72	44.00 gh	48.50 b-e	87.50 jk	15 a-e	3.55 h-m
G31	226.33	112.30	45.00 e-h	47.00 de	90.50 g-k	15 a-e	3.65 f-m
G32	247.17	121.44	50.00 a	53.00 a	100.50 a	14 b-e	4.15 b-e
G33	236.67	118.63	48.50 a-d	52.50 ab	97.50 a-e	15 a-e	4.00 c-h
G34	210.83	106.49	50.00 a	53.00 a	100.50 a	15 a-e	3.90 d-i
G35	229.33	116.53	48.00 a-e	51.50 abc	95.50 a-g	17 abc	4.20 bcd
G36	260.67	132.72	49.00 abc	52.50 ab	98.50 a-d	15 a-e	3.45 im
G37	221.17	114.05	49.00 abc	51.50 abc	98.50 a-d	17 abc	3.40 j-m
G38	182.00	91.70	49.00 abc	51.50 abc	98.50 a-d	16 a-d	4.15 b-e
G39	225.50	114.80	48.00 a-e	49.50 a-e	96.50 a-f	16 a-d	3.70 e-m
G40	218.17	110.00	47.50 a-f	50.50 a-e	96.00 a-f	13 cde	3.60 g-m
G41	234.33	119.28	49.00 abc	52.50 ab	99.00 abc	15 a-e	3.40 j-m
G42	207.33	107.34	48.00 a-e	51.00 a-d	97.00 a-e	14 b-e	3.85 d-j
G43	225.07	113.42	49.50 ab	52.00 abc	99.50 ab	14 b-e	4.05 c-g
G44	225.00	115.39	49.00 abc	50.50 a-e	98.00 a-d	15 a-e	3.95 c-h
G45	201.67	102.72	48.00 a-e	52.00 abc	96.50 a-f	14 b-e	3.65 f-m
G46	229.50	117.23	47.50 a-f	49.50 a-e	95.50 a-g	15 a-e	4.40 abc
BISI-2 (G47)	211.00	103.38	48.00 a-e	52.50 ab	96.50 a-f	11 e	3.30 lm
Jakaring (G48)	207.50	102.73	49.00 bc	52.50 ab	99.50 ab	13 cde	4.60 ab
Pioneer (G49)	216.50	97.61	47.00 a-g	50.50 a-e	93.50 d-i	17 abc	4.75 a

Note: PH = plant height, EH = ear height, D50%T = Days to 50% tasselling, D50%S = Days to 50% silking, HA = Harvest age, NKR = number of kernel rows, and ED = ear diameter. The numbers followed by the same letter in the same column are not significantly different according to the 5% HSD test.

Table 3. Average of ear length, kernel length, kernel width, kernel thickness, 1000-kernel weight, and production per hectare in 49 maize plant genotypes.

Genotype	Characteristic					
	EL (cm)	KL (mm)	KW (mm)	KT (mm)	1000-KW (g)	PPH (kg)
G1	17.25 abc	9.60 d-h	8.15 bcd	4.75 c-f	0.24 a-d	5071.43 bcd
G2	18.35 a	8.65 l-p	7.45 g-k	4.05 i-l	0.18 l-p	5488.09 ab
G3	11.75 q-t	8.80 k-p	7.50 f-j	4.40 e-j	0.20 f-m	2571.43 st
G4	14.70 hij	8.45 n-r	7.50 f-j	4.60 d-g	0.19 k-p	3821.43 i-p
G5	14.50 h-l	7.75 tu	7.10 k-n	4.10 h-l	0.18 l-p	3190.48 p-q
G6	12.25 p-t	9.50 e-i	7.05 lmn	4.00 j-m	0.19 k-p	3523.81 m-q
G7	16.55 b-g	9.45 f-j	7.70 efg	4.70 c-f	0.23 c-g	5214.29 bc
G8	13.80 i-o	8.60 l-q	7.45 g-k	4.20 g-k	0.12 u	3261.90 o-r
G9	15.10 ghi	9.10 h-l	7.75 efg	4.05 i-l	0.21 f-l	3107.14 qrs
G10	16.25 c-g	9.00 i-m	7.75 efg	4.80 cde	0.22 e-i	2833.33 rs
G11	17.85 ab	10.25 abc	9.00 a	4.55 d-g	0.24 a-d	3821.43 i-p
G12	12.70 m-s	9.85 c-f	6.95 mno	3.90 k-n	0.18 l-p	3607.14 k-q
G13	18.35 a	8.50 m-r	8.25 bc	4.45 d-i	0.23 c-g	2166.67 t
G14	17.25 abc	8.05 rst	8.20 bcd	5.55 a	0.17 o-s	4047.62 g-m
G15	14.65 h-k	10.00 b-e	7.85 def	3.85 k-n	0.21 f-l	3595.24 l-q
G16	14.70 hij	9.00 i-m	7.55 f-i	4.60 d-g	0.19 k-p	3821.43 o-r
G17	15.35 e-h	8.65 l-p	8.50 b	4.50 d-h	0.21 f-l	3321.43 o-r
G18	14.20 h-m	7.90 stu	7.45 g-k	5.25 ab	0.21 f-l	3488.10 n-q
G19	16.80 b-e	9.00 i-m	7.15 j-n	5.25 ab	0.26 a	5654.76 ab
G20	14.70 hij	10.65 a	7.55 f-i	4.10 h-l	0.22 e-i	4833.33 cde
G21	11.55 st	9.10 h-l	7.40 g-l	4.40 e-j	0.21 f-l	4345.24 e-i
G22	11.70 rst	8.40 o-s	7.05 lmn	4.65 def	0.19 k-p	3535.71 m-q
G23	12.35 o-s	9.10 h-l	7.70 efg	3.15 p	0.17 o-s	3464.29 n-r
G24	13.05 l-s	9.10 h-l	7.55 f-i	3.60 mno	0.14 tu	3833.33 i-o
G25	12.50 n-s	8.90 k-o	6.90 nop	3.75 l-o	0.19 j-p	3273.81 o-r
G26	12.70 m-s	8.50 m-r	7.55 f-i	4.85 bcd	0.24 a-d	3095.24 qrs
G27	17.75 abc	9.10 h-l	6.55 pqr	4.70 c-f	0.22 e-i	4678.57 c-g
G28	13.15 k-r	9.00 i-m	6.60 o-r	4.40 e-j	0.18 l-p	4309.52 e-j
G29	11.65 rst	7.40 u	7.30 h-m	3.50 nop	0.15 rst	3785.71 i-p
G30	13.25 j-q	10.65 a	7.25 i-n	3.40 op	0.18 l-p	4190.48 f-l
G31	17.45 abc	8.90 k-o	6.65 opq	4.70 c-f	0.20 f-m	5952.38 a
G32	16.90 a-d	9.50 e-i	7.40 g-l	3.75 l-o	0.23 c-g	5500.00 ab
G33	14.60 h-k	9.20 g-k	7.10 k-n	3.70 l-o	0.18 l-p	4476.19 d-h
G34	15.40 d-h	10.40 ab	7.55 f-i	4.40 e-j	0.19 k-p	4821.43 c-f
G35	17.35 abc	10.05 bcd	7.65 e-h	4.45 d-i	0.22 e-i	5607.14 ab
G36	13.75 i-p	9.80 c-f	8.15 bcd	4.50 d-h	0.25 ab	3702.38 ab
G37	13.90 h-n	8.05 rst	7.45 g-k	4.45 d-i	0.17 o-s	3845.24 h-o
G38	10.80 t	8.95 j-n	7.50 f-j	3.70 l-o	0.16 q-t	3071.43 qrs
G39	14.60 h-k	9.10 h-l	6.50 qr	3.85 k-n	0.15 t	5297.62 bc
G40	14.55 h-l	8.05 rst	6.25 r	4.00 j-m	0.14 tu	4511.91 d-g
G41	11.75 q-t	8.00 rst	7.85 def	5.10 bc	0.15 rst	4261.90 e-j
G42	14.00 h-n	8.10 q-t	6.40 qr	4.60 d-g	0.17 o-s	4285.71 e-j
G43	17.35 abc	9.65 d-g	8.00 cde	3.75 l-o	0.20 f-m	3488.10 n-q
G44	13.50 j-p	9.50 e-i	7.75 efg	4.05 i-l	0.21 f-l	4500.00 d-g
G45	12.35 o-s	9.80 c-f	7.55 f-i	4.55 d-g	0.21 f-l	4154.76 g-m
G46	17.00 abc	9.45 f-j	8.20 bcd	4.70 c-f	0.23 c-f	5690.48 ab
BISI-2 (G47)	13.30 j-p	8.80 k-p	7.75 efg	3.80 k-o	0.22 e-i	3500.00 n-q
Jakaring (G48)	16.75 b-f	9.65 d-g	9.10 a	4.35 f-j	0.24 a-d	4238.09 e-k
Pioneer (G49)	15.25 f-i	8.35 p-s	7.45 g-k	4.10 h-l	0.22 e-h	3250.00 o-r

Note: EL = ear length, KL = kernel length, KW = kernel width, KT =kernel thickness, 1000-KW = 1000-kernel weight, and PPH = production per hectare. The numbers followed by the same letter in the same column are not significantly different according to the 5% HSD test.

3.3 Kernel length, kernel width, kernel thickness, 1000-kernel weight, and production per hectare

The characteristics of kernel length, kernel width, kernel thickness, 1000-kernel weight, and production per hectare had significant differences among all genotypes tested (Table 3). The kernel length characteristics of

hybrid maize candidates range from 7.40 mm to 10.65 mm. G29 has the longest kernel length (10.65 mm), while G20 and G30 have the shortest kernel length (10.65 mm). The kernel width characteristics of hybrid maize candidates range from 6.25 mm to 9.00 mm. G40 has the smallest kernel width (6.25 mm), while G11 has the largest kernel width (9.00 mm). Furthermore, the kernel thickness characteristics of the hybrid maize candidates ranged from 3.15 mm to 5.55 mm. G23 has

the lowest seed thickness (3.15 mm), while G14 has the highest thickness (5.55 cm).

The characteristic of 1000-kernel weight in hybrid maize candidates ranges from 0.12 kg to 0.26 kg. G8 has the lowest 1000-kernel weight (0.12 kg) while G12 has the highest 1000-kernel weight (0.26 kg). The characteristics of production per hectare in hybrid maize range from 2166.67 kg to 5952.38 kg per hectare. G13 has the lowest characteristics of production per hectare (2166.67 kg per hectare), while G31 has the highest characteristics of production per hectare (5952.38 kg per hectare).

3.4 Correlation between quantitative characters

Correlation analysis is used to determine the closeness of the relationship between the observed characters [17] [18] [19] [20]. Based on the research results in Table 4 show that the genotype correlation coefficient of all observed characters has both negative and positive values. A negative correlation indicates that increasing one character will decrease another character, while a positive correlation occurs when increasing one character will increase another correlated character [21]. Table 4 shows that seed length significantly correlates positively with production per hectare. The kernel length is significantly positively correlated with the

production per hectare. The 1000-kernel weight is significantly positively correlated with ear diameter, ear length, kernel length, kernel width, and kernel thickness. The ear length character was significantly positively correlated with kernel thickness. Harvest age is significantly positively correlated with days to 50% tasselling and days to 50% silking. Days to 50% tasselling is significantly positively correlated with days to 50% silking. Plant height had a significant positive correlation with ear height.

The production character per hectare is the main character that has economic value. Indirect selection is often carried out if there is a positive correlation in characters that have economic value (production per hectare) to save time, energy, and costs when carrying out selection. In this study, production per hectare had a significantly positive correlation with kernel length characteristics. A significant positive correlation between these two characters is ineffective in implementing indirect selection because both characters are characters in the generative phase. Indirect selection of the two characters produced in the generative phase does not save time, energy, and costs. The production character per hectare has an insignificant positive correlation with plant height, so indirect selection for both characters can be carried out. Selection for plants that have plant height will indirectly select plants with high production per hectare.

Table 4. Correlation coefficient between characters in 49 maize genotypes tested.

	PH	EH	D50%T	D50%S	HA	NKR	ED	EL	KL	KW	KT	1000-KW	PPH
PH	1.00												
EH	0.96**	1.00											
D50%T	-0.06	-0.02	1.00										
D50%S	-0.04	-0.04	0.80**	1.00									
HA	-0.07	-0.02	0.98**	0.79**	1.00								
NKR	-0.07	-0.13	-0.24	-0.21	-0.25	1.00							
ED	-0.04	-0.08	-0.06	-0.03	-0.06	-0.16	1.00						
EL	0.20	0.19	-0.04	-0.13	-0.02	0.04	0.37*	1.00					
KL	0.10	0.13	0.08	0.05	0.07	-0.09	0.13	0.19	1.00				
KW	0.16	0.15	0.18	0.22	0.20	-0.08	0.27	0.30	0.26	1.00			
KT	0.13	0.18	-0.12	-0.12	-0.11	0.10	0.02	0.32*	-0.22	0.17	1.00		
1000-KW	0.26	0.26	-0.06	-0.04	-0.07	-0.12	0.38*	0.46**	0.38*	0.45**	0.33*	1.00	
PPH	0.08	0.12	-0.11	-0.20	-0.12	-0.12	0.04	0.21	0.38*	-0.16	0.11	0.18	1.00

Note: PH = plant height, EH = ear height, D50%T = Days to 50% tasselling, D50%S = Days to 50% silking, HA = harvest age, NKR = number of kernel rows, ED = ear diameter, EL = ear length, KL = kernel length, KW = kernel width, KT =kernel thickness, 1000-KW = 1000-kernel weight, and PPH = production per hectare.
 **significant at 5% and 1% level of probability, respectively.

3.5 Selected hybrid maize candidate in variety release

This study tested maize hybrid candidates for maize development on dry land. Maize grown on dry land must have the characteristics of an early harvest age and high production [22]. The characteristics of harvest time and high production are the characteristics that are of primary concern because the rainy months on dry land are around three to four months [23] and have low productivity [24]

Based on harvest age, maize is divided into three groups, namely (1) short or early maturing (75-95 days), (2) medium maturing (95-120 days), and (3) long maturing (more than 120 days). [25]. The hybrid maize

candidate has a harvest age of around 87.00 – 100.50 days, so the hybrid maize candidate has an early harvest age and a medium harvest age. Harvest age for comparison corn varieties (Bisi-2, Jakaring, and Pioneer) ranges from 93.50 – 99.50 days. Thirteen hybrid maize candidates have a shorter harvest age compared to the three comparison varieties, namely G1 (91.50 days), G2 (91.50 days), G4 (87.50 days), G5 (88.50 days), G6 (87.50 days), G9 (91.50 days), G16 (90.00 days), G19 (90.50 days), G22 (92.50 days), G26 (90.50 days), G30 (87.50 days), and G31 (90.50 days) (Table 2). The harvest age character has an insignificant negative correlation with production per hectare (Table 4). Based on the correlation results, the higher the production per hectare character, the tendency for the harvest age to be shorter.

Maize candidates with high production per hectare exceed the three comparison varieties, and there are as many as seventeen hybrid maize candidates. Seventeen hybrid maize candidates with production per hectare exceeding the three comparison varieties were selected

as hybrid maize candidates with production above 5000.00 kg per hectare. The research results selected G1, G2, G7, G16, G31, G32, G35, G39, and G46 (Figures 1 and 2) as candidates for varieties with high production and early and medium harvest age.

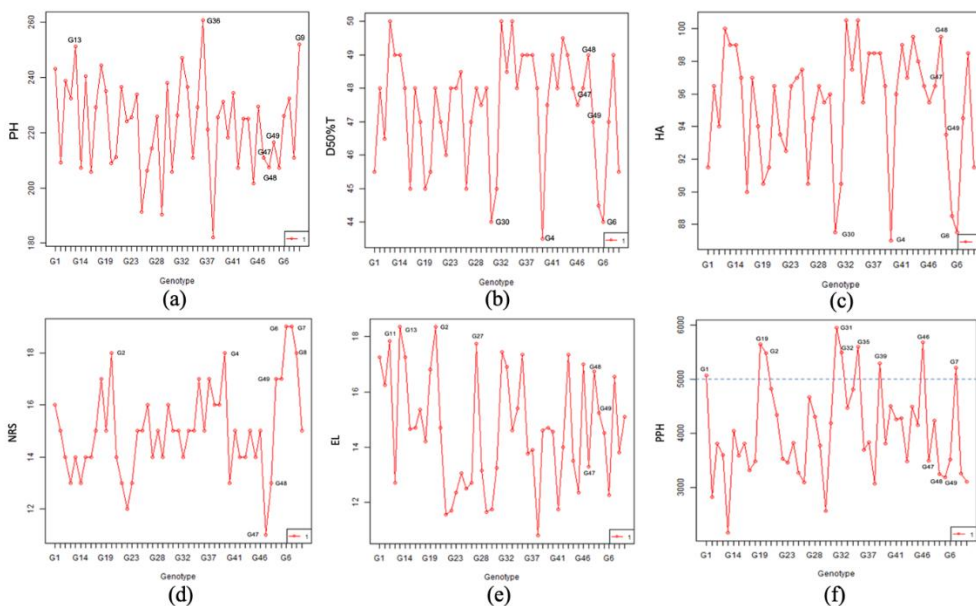


Fig. 1. Graph of 49 genotypes for characters: (a) plant height, (b) days to 50% tasselling, (c) days to 50% silking, (d) harvest age, (e) ear length, (f) Production per hectare.

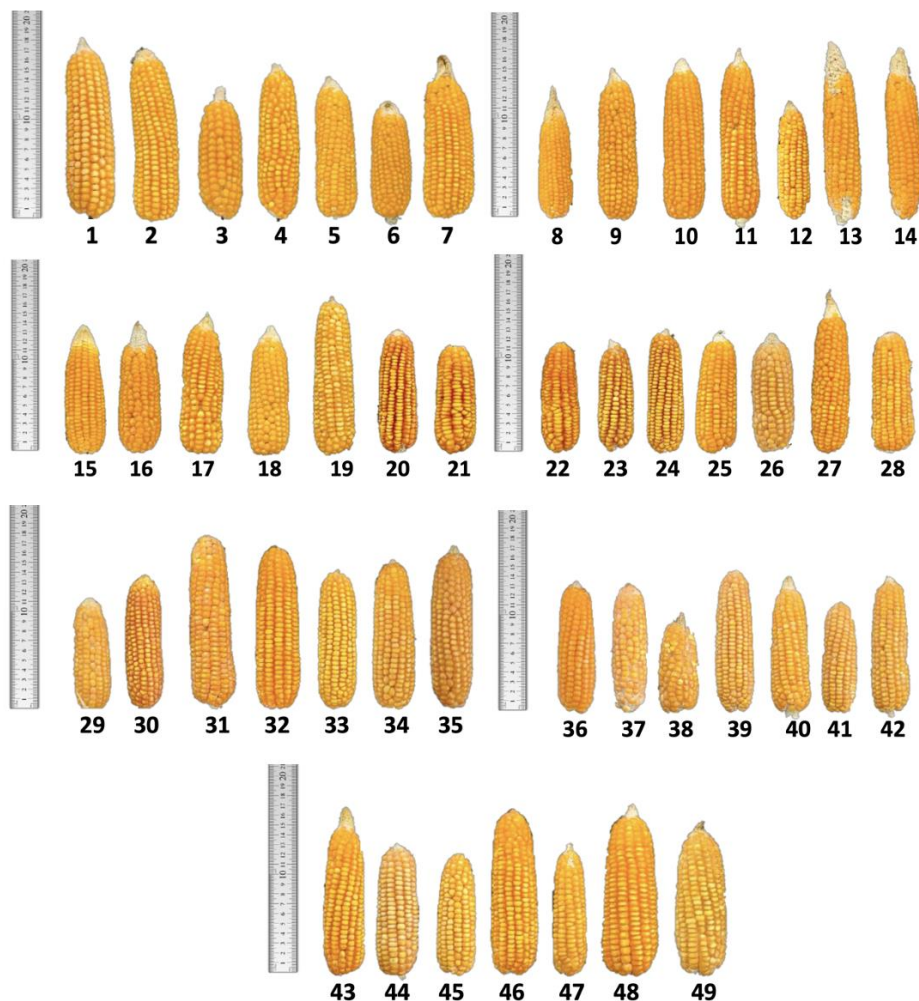


Fig. 2. Appearance of the ear of 49 maize genotypes.

4 Conclusion

The results showed that several plant characters from the 49 genotypes tested had significant differences except for the characteristics of plant height and ear height. Characteristics of production per hectare were significantly positively correlated with kernel length. G1, G2, G7, G16, G31, G32, G35, G39, and G46 are selected hybrid maize candidates for further testing in variety release because they have early and medium harvest age and high production per hectare (above 5,000 kg per hectare).

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