Effect of population level of various hybrid corn strains on growth and yield

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Abstract. The success of plant breeding efforts is the availability of genetic diversity in the population so that people can choose what is preferred due to limited optimal land by utilizing sub-optimal land. The level of plant population is carried out to obtain information about a prospective maize variety that has a high productivity in land with limited / minimal level of sunlight. The higher level of plant population means the lower the reception of light by plants, therefore we need a variety that is shade resistant. The purpose of this study was to determine the effect of the population level of each unit area on various shade resistant lines with high productivity which is expected to be applied on intercropping land (plantations / forests) that have high shade levels. The study was conducted at Cereals Plant Research Institute, Maros in August - November 2016. The study used a randomized block design in the form of a split plot with 3 replications. The main plot is the plant population, which is a medium population of 70 cm x 20 cm (population 71,428 plants/ha) and a population of height 70 cm x 15 cm (population 95,238 plants/ha). As subplots were 10 prospective varieties of hybrid corn strain. The results showed that the shade resistant strain of 70 x 15 cm plant spacing highest yields of 1044.9 x 1027-11 (7.75 t/ha) and 70 x 20 cm spacing yield (t/ha) the highest CY 15 x MAL 03 (10.07 t/ha).

1. Introduction

Agricultural extensification for maize is highly required along with the shifting of fertile land for non-agriculture purposes, thus maize crops directed to problem areas such as drought-prone land and utilizing land under hardwood stands [1]. Therefore, the mass conversion of fertile land for non-agriculture needs a breakthrough by develop shade resistant maize genotypes to cultivate under the stands of woody plants (i.a teak and coconut) and through an increase plant population[2–4]. Requirements for successful breeding efforts is the availability of genetic diversity in the population and how large the genetic diversity is [5,6]. Furthermore, a population does not show genetic diversity, the diversity that is seen is the diversity of phenotypes which is diversity caused by environmental factors [7].

Maize productivity is influenced by, among others, varieties and environmental factors. As for increasing production, among others, by spacing (population level per unit area) and having leaf types on the cob is upright[8]. Types of upright leaves the level of receiving sunlight is greater than the type of flat/drooping leaves. Regulating plant population by adjusting spacing accordingly is one of the intensification programs to increase the rate of crop production, but indirectly spacing can affect the intensity of sunlight which is an energy source for plant photosynthesis[9].
Increasing plant population regulation causes density per unit area of land. Several experiments proved that the increasing of density affected to the response in the morphological and physiological characteristics of maize, including delaying the release of anthesis and increasing the number of empty cobs. Increased empty cob because of the lack of synchronization of pollination of male and female flowers caused by plant spacing (population) can also occur due to drought stress in that phase [10–12]. Plant population (spacing) is one of the factors that can influence yield, therefore to increase yield of maize can be attempted through planting density until it reaches the optimal population [13].

Efforts to increase plant populations can be pursued by finding lines that are resistant to shade. Shade resistant strains are expected with limited light capable of producing optimally with low photosynthesis. The process of photosynthesis is important in plant growth and seed formation. Photosynthesis is a basic process in plants to produce food for the availability of energy for plant growth and development and some of the results of photosynthesis are translated into seeds [14].

The purpose of this study was to determine the effect of the population level of each unit area on various shade-resistant lines with high productivity which is expected to be applied on intercropping land (plantations/forests) that have high shade levels.

2. Materials and Methods
The study was conducted in August - November 2016 at the Maros experimental station, Indonesian Cereals Research Institute. The study used a randomized block design in the form of a split plot with 3 replications. The main plot is the plant population, which is a medium population of 70 cm x 20 cm (population 71,428 plants/ha) and a population of height 70 cm x 15 cm (population 95,238 plants/ha). As subplots were 10 prospective varieties of hybrid corn strain. Planting 2 seeds per hole is planted and at 10 days thinning is carried out until one plant/clump is grown. The plot size of each treatment is 2.8 m x 6 m.

The dosage of fertilizer used is 400 kg/ha ponska, and 400 kg/ha urea. Fertilization is done 2 times, all Ponska fertilizers are given at the age of 7-10 days after planting and urea fertilizer is given at 40 days after planting. For maintenance, weeds are mainly carried out by spraying the herbicide Calaris/chonvey with a dose of 2.0 l/ha given before the first fertilization. Weeding and growing before the second fertilization is done manually in each row of plants.

Observed data: plant height (30 and 75 days after planting), height of the cob (75 days after planting), leaf angle (75 days after planting), leaf chlorophyll value (30 and 75 days after planting), leaves (long, width, amount) 75 days after planting, age of flowering (male and female), yield (t/ha) and yield components (yield, length and diameter of cobs, amount of rows and seeds in rows).

3. Results and Discussion

3.1 Vegetative and Generative Character
The results of the analysis showed that plant height with spacing of 70 x 15 cm at 30 days after the various lines were significantly different between lines, but this did not significantly indicate that between lines still gave the same ability to plant height at 30 days after planting. The highest plant height values were strains AMB 07 x CML 161 (54.72 cm) and the lowest were strains MAL 3 x CY 4 (36.66 cm) (Table 1).

Plant height and location of the cobs at 75 days after planting between lines showed significantly different at 70 x 20 cm spacing. Of the various lines with spacing, the values give significant differences in certain lines to plant morphology. This shows that the lines gave a high response to plant spacing, besides being influenced by the gene factors of each genotypes. The highest plant height value of 75 days after planting is G 02 x 5 line (211.66 cm) and the lowest is MAL 3 x CY 4 (169.11 cm), while the height of the highest cob location is G 02 x 5 (91.44 cm) and the lowest is MR 12 x MAL 04 (66.33 cm) (Table 1).

The results of the analysis showed that the leaf angle was significantly different in various lines with a spacing of 70 x 20 cm. This result shows that the various lines have different plant morphological
characteristics which are influenced by the nature of plant genes and the level of density of plant populations. Morphological characteristics of plants that have a small leaf angle will receive greater solar radiation compared to plants that have a large leaf angle. A low leaf angle will provide a large opportunity for weed growth, but the population rate per hectare can be increased. Plant density regulation aims to minimize competition between plants so that the canopy and plant roots can utilize the environment optimally, but dense plant numbers will reduce yields due to competition for nutrients, water, solar radiation and growing space so that it will reduce the number of seeds per plant [15,16]. The highest leaf angle values of G 02 x 7 (62.500) and the lowest AMB07 x CML 161 (42.880) (Table 1).

Chlorophyll value of leaves in 30 days after planting showed that from various lines ranging from 43.71 - 50.32 units, between lines gave a different chlorophyll value, indicating that the ability of plants to absorb nutrients was still the same (Table 1). While the chlorophyll value in 75 days after planting of all lines was higher than 30 days after each line. The highest value was 75 days after planting strain MAL 01 x 4 (57.89 units) and the lowest was MAL 3 x CY 4 (52.24 units) (Table 1). The results of the analysis showed that the leaf chlorophyll value at 75 days after planting was very significantly different, this showed that the ability of plants to absorb nutrients available in the soil greatly affected the leaf chlorophyll value. The level of ability and needs differ depending on the type of gene and strain, thus showing differences in the value of chlorophyll.

The analysis showed that leaf length and width 75 days after planting were significantly different. This shows that each strain has different morphological characteristics that are affected by harvest age and planting distance. Yulisma (2011) reports that in general the morphological differences between deep and early maturing varieties include plant height, leaf length and width. The longest value of leaf length G 02 x 5 (83.77 cm) and the shortest MAL 8 x MAL 01 (67.44 cm), while the largest leaf width is Mal 01 x 4 (9.48 cm) and the smallest MR 12 x MAL 04 (7.23 cm) (Table 1).

The number of leaves 75 days after planting shows significantly different from various lines, this is the number of leaves affected by the morphological nature of the plant. The highest number of leaves is 1044-9 x 1027-11 (13.66) and the smallest is MR 12 x MAL 04 (11.88) (Table 1). In general, the number of leaves correlates with the number of segments and plant height that affect the yield of seeds. The number of leaves of the C3 population varies between 10-14 and correlates closely and positively to the yield and heritability value of broad meaning, therefore the number of leaves can be used for selection to improve yield [17–19].

The age of flowering male and female differ significantly from the various lines, this shows that the age of flowering is influenced by the genetic traits of the strain and population density per hectare. The highest age of male flowering is B 11 x 11 (55 days after planting) and MR 12 x MAL 04 (49.33 days after planting), while the age of flowering females is the highest value of MAL 3 x CY 4 (58.66 days after planting) and lowest MAL 8 x MAL 01 (52 HST) (Table 1).

Criteria for assessing high and low population diversity based on genetic diversity coefficient values are low diversity (> 25%), rather low (25% <50%), high enough (50% <75%) and high (> 75%) (Moedjiono and Mejaya, 1994 in [20]). Table 1 shows that the diversity coefficient values ranged from 2.09% - 18.70% in vegetative and generative characters, so including the low coefficient of diversity values. The coefficient of diversity is a measure of the diversity of characters observed in a population [21].
Table 1. Averages of some vegetative and generative characters of shade resistant lines at 70 x 15 cm plant spacing (population of 95,238 plants/ha). Maros, 2016.

| Genotypes     | PH 30 DAP | PH 75 DAP | HoC (cm) | LA (%) 75 DAP | LC 30 DAP (Unit) | LC 75 DAP (Unit) | LL 75 DAP (Unit) | LW 75 DAP | NoL. 75 DAP | Anthesis (days) | Silking (days) |
|---------------|-----------|-----------|----------|---------------|------------------|------------------|------------------|------------|-------------|----------------|---------------|
| 1044-9x1027-11 | 46.38ab   | 190.00ab  | 76.94abc | 44.66ef       | 47.42ab          | 57.17ab          | 75.66a-d        | 7.17e      | 13.66a      | 49.66de        | 53.66ed       |
| AMB07xCML 161 | 54.72a    | 186.05ab  | 74.66bc  | 42.88f        | 48.28ab          | 56.26abc         | 77.72ab         | 7.45cd     | 13.05ab     | 49.66de        | 53.66cd       |
| G 02 x 5      | 45.94ab   | 211.66a   | 91.44a   | 62.50a        | 50.32a           | 57.84a           | 83.77a          | 8.46abc    | 13.50a      | 54.33ab        | 57.66ab       |
| G 02 x 7      | 48.66ab   | 186.39ab  | 86.61ab  | 53.94bc       | 46.06ab          | 55.25abc         | 78.83ab         | 8.59ab     | 13.06ab     | 53.00bc        | 56.33bc       |
| MR 12 x MAL 04 | 45.27ab  | 182.11b   | 66.33c   | 46.94def      | 47.33ab          | 57.81ab          | 68.50cd         | 7.23e      | 11.88c      | 49.33e         | 53.66cd       |
| MAL 3 x CY 4   | 36.66b    | 169.11b   | 74.94bc  | 49.44cde      | 43.71b           | 52.24c           | 71.44bcd        | 7.84-e     | 12.89abc    | 54.00ab        | 58.66ac       |
| MAL 01 x 4    | 37.89b    | 179.67b   | 72.00bc  | 54.61bc       | 47.37ab          | 57.89a           | 77.94ab         | 9.48a      | 12.78ac     | 51.33cd        | 55.66bc       |
| CY 15 x MAL 03 | 39.50b   | 176.45b   | 77.94abc | 50.94bcd      | 46.07ab          | 55.48abc         | 78.50ab         | 8.34bcd    | 13.55a      | 54.33ab        | 56.00abc      |
| B 11 x 11     | 44.78ab   | 186.56ab  | 83.00ab  | 55.61b        | 44.35b           | 54.33abc         | 76.00abc        | 7.91bc-e   | 13.00ab     | 55.00a         | 58.00ab       |
| Average       | 45.44     | 184.39    | 8.36     | 51.40         | 46.91           | 55.77            | 75.58           | 7.98       | 12.96       | 51.80          | 55.53         |
| CV (%)        | 18.70     | 8.96      | 11.03    | 6.47          | 6.94            | 4.56             | 6.84            | 8.11       | 4.58        | 2.09           | 2.94          |

PH = Plant Height, HoC Height of Cob, LA = Leaf angle (°), LC = Leaf Chlorophyll, LL = Leaf length, LW = Leaf width, NoL. = Number of leaves. The number followed by the same letter is not significantly different at the 5% level according to the Duncan test.

The results of the analysis showed that significantly different plant spacing of 70 x 20 cm in 30 days after planting, but the difference was not significant. This shows that the spacing still provides almost the same ability depending on the nature of the line genes. While in 75 days after planting height was significantly different between lines. This shows that the nature of genes has been seen that the ability to plant spacing and morphological characteristics of plant genes are significant. High density plant received less radiation, and trigger the elongation of cell through several metabolism system in the result plant stem growth higher than sufficient light plant [22–25]. The highest value of plants at 30 days after planting the highest G 02 x 7 line (50.55 cm) and the lowest MAL 3 x CY 4 (25.16 cm), while the highest value at 75 days after planting G 02 x 7 (195.33 cm) and the lowest MAL 3 x CY 4 (25.16 cm) (Table 2).

The highest value of the location of the cobs in 75 days after planting with the highest spacing of 70 x 20 is G 02 x 5 (93.50 cm) and the lowest is MR 12 x MAL 04 (65.77 cm) (Table 2). The results of the analysis showed that the height of the location of the cobs was significantly different between the lines, but it did not signify the difference. In general, the height of the location of the cobs correlates with the height of the plant, i.e the greater the value of the plant height, the higher the location of the cobs is also higher.

The results of the analysis showed that the leaf angles of the various strains were significantly different. The largest leaf angle values are G 02 x 7 (60°) and the smallest is AMB 07 x CML 161 (41°) (Table 1). The leaf angle value will affect the level of sunlight's acceptance by plants and the level of nutrient absorption by plants. Planting distance that is too wide in addition to reducing plant population per unit area also causes a reduction in the use of direct sunlight to the ground and a reduction in nutrients that occur evaporation due to direct sunlight to the soil surface, so that nutrients are lost due to evaporation and leaching [13].

The analysis showed that leaf chlorophyll 30 days after planting and 75 days after planting at 70 x 20 cm spacing were significantly different. But of the various lines the difference is not significant, this shows that each line still provides almost the same ability between lines. The highest value of 30 days after planting chlorophyll G 02 x 5 (52.55 units) and the smallest MR 12 x MAL 04 (46.26 units), were 75 days after planting the highest value of MAL 8 x MAL 01 (58.73 units) and the smallest MAL 01 x 4 (53.13 units) (Table 2).

The length and width of the leaves of the analysis result show that the difference is significant, this shows that the character of the plants from the various lines gives the optimum in accordance with the ability of the plant itself to plant spacing. The longest leaf length values G 02 x 5 (86.83 cm) and the shortest MR 12 x MAL 04 (66.83 cm), the widest leaf width MAL 01 x 4 (10.50 cm) and the narrowest MAL 8 x MAL 01 (7.30 cm) (Table 2).
The number of leaves 75 days after planting with a spacing of 70 x 20 cm results of the analysis show that it is significantly different, this shows that the number of leaves is influenced by the nature of the plant genes that are able to provide in accordance with the ability of the plant itself which will ultimately affect the yield of seeds. According to Sudika et. al (1998) reported that the number of leaves of the C3 population varied from 10 to 14 which was closely and positively correlated to the yield and heredity of broad significance was 77.75%, so the number of leaves could be used as a selection to improve yields.

The results of the analysis showed that the spacing of 70 x 20 cm age of male and female flowering was significantly different, this shows that each genotype had different properties according to the ability of the plant itself to plant spacing. Plant spacing will affect flowering age depending on the level of population density due to competition for sunlight and nutrient availability in the soil. Similar to Increasing density per unit area can result in changes in the morphological and physiological characteristics of maize, including delays in the anthesis and an increase in the number of non-seeded cobs which is positively correlated with increasing levels of plant population density[16]. The highest value of flowering age is MAL 3 x CY 4 (55.33 days) and the smallest MR is 12 x MAL 04 (48.66 days), female flowers have the largest value of MAL 3 x CY 4 (57.66 days) and the smallest MR 12 x MAL 04 (51.00 days) (Table 2). The difference in the value of these parameters is caused by environmental factors and the type of strain caused by different types of plants. The effect of the observed varieties on the observed variables was due to differences in genetic factors possessed by each maize variety and the ability to adapt to the environment [26].

Table 2. Average of some vegetative and generative characters of shade resistant lines at 70 x 20 cm spacing (population 71,428 plants/ha). Maros, 2016.

| Genotypes | PH 30 (cm) | PH 75 DAP | HoC (cm) | LA (°) 75 DAP | LC 30 DAP (Unit) | LC 75 DAP (Unit) | LL 75 DAP (Unit) | LW 75 DAP | NoL 75 DAP | Anthesis (days) | Silking (days) |
|-----------|-----------|-----------|---------|--------------|-----------------|-----------------|-----------------|---------|---------|--------------|-------------|
| 1044-9 x 1027-11 | 39.55b | 184.78abc | 80.50b | 45.05de | 49.76ab | 59.00a | 73.33ef | 7.42de | 13.05ab | 50.33cde | 54.00bcd |
| AMB 07xCM 161 | 47.44ab | 182.38abc | 76.55bc | 41.77e | 50.01ab | 59.24a | 78.33bc | 8.06bc | 13.00ab | 51.33cd | 55.66abc |
| G 02 x 5 | 46.50ab | 195.33a | 93.50a | 60.77a | 52.55a | 59.07a | 86.83a | 8.17bc | 13.83a | 54.00ab | 57.66a |
| G 02 x 7 | 53.00a | 176.61bc | 74.72bc | 51.05bc | 48.16ab | 57.44a | 79.50c | 8.73b | 12.05bc | 49.33de | 52.66cd |
| MR 12 x MAL 04 | 45.55ab | 171.33cd | 65.77c | 47.27cde | 46.26b | 56.56ab | 66.83g | 7.81cde | 11.39c | 48.66e | 51.00d |
| MAL 3 x CY 4 | 25.16c | 161.39d | 67.22c | 45.66de | 46.82e | 54.20bc | 71.17f | 7.94cde | 12.16bc | 55.33a | 58.33a |
| MAL 01 x 4 | 40.44ab | 187.72ab | 76.61bc | 50.15cde | 49.12ab | 53.13c | 84.83b | 10.50a | 13.55a | 52.33bc | 56.33ab |
| MAL 8 x MAL 01 | 37.61bc | 180.83bc | 71.94ab | 49.77cde | 49.09ab | 58.73a | 67.77g | 7.30c | 12.22bc | 48.66e | 51.66d |
| CY 15 x MAL 03 | 39.22b | 178.16bc | 76.44ab | 54.99abc | 48.63ab | 57.03a | 80.94bc | 8.72b | 13.72a | 53.66ab | 56.66ab |
| B 11 x 11 | 47.89ab | 185.50ab | 81.00b | 54.94ab | 47.82ab | 57.34a | 75.00def | 8.36bc | 13.94a | 53.66ab | 56.00ab |
| Average | 42.23 | 180.50 | 76.42 | 50.54 | 48.83 | 57.18 | 76.45 | 8.30 | 12.89 | 51.73 | 55.00 |
| CV(%) | 18.40 | 4.39 | 8.44 | 9.79 | 6.28 | 3.07 | 4.04 | 5.33 | 5.06 | 2.47 | 3.41 |

3.2 Yield and Yield Components

Analysis of the various lines showed that the yield of dried seeds per hectare and seed yield was significantly different, but the difference was not significant between lines. This shows that with a spacing of 70 x 15 cm several lines obtained yields per hectare and seed yield is almost the same due to the ability of plants to plant spacing in utilizing sunlight and nutrients in the soil that are almost the same besides being influenced by genetic factors. The highest yield is 1044-9 x 1027-11 (7.75 t / ha) and the smallest is B 11 x 11 (5.04 t / ha), while the highest yield of seeds is 1044-9 x 1027-11 and MAL 01 x 4 (0.75%) (Table 3).

The results of the analysis showed that the weights of 100 seeds, cob length, ear diameter, number of rows per cob and number of seeds in one row were significantly different. This shows that from various varieties with a spacing of 70 x 15 cm had a significant effect on these parameters. The density of plants will affect the physiological properties of plants including seed weight, cob length, ear diameter, number of rows and number of seeds in a row. The highest weight value of 100 seeds MAL 01 x 4 (37.85 g) and the smallest MAL 3 x CY 4 (25.19 g), the longest cob length MR 12 x MAL 04 (15.42 cm) and the smallest B 11 x 11 (12.96 cm), the biggest cob diameter is 1044-9 x 1027-11 (4.59 cm) and the smallest is B 11 x 11 (4.20 cm), the largest number of rows is 1044-9 x 1027-11 (15.22) and...
the smallest B11 x 11 (4.20), the number of seeds in the largest row 1044-9 x 1027-11 (31.61) and the smallest B 11 x 11 (24.66) (Table 3).

| Genotypes          | Yield (t/ha) | Yield (%) seeds | Weight 100 seeds (g) | Cob length (cm) | Cob diameter (cm) | Number of rows | Number of seeds in a row |
|--------------------|--------------|-----------------|----------------------|-----------------|-------------------|-----------------|-------------------------|
| 1044-9 x 1027-11   | 7.75a        | 0.75a           | 29.08abc             | 14.55abc        | 4.59a             | 15.22a          | 31.61a                  |
| AMB 07xCML 161     | 7.19a        | 0.73ab          | 31.32b               | 14.49abc        | 4.45abc           | 14.00ab         | 30.27abc               |
| G 02 x 5           | 7.14a        | 0.73ab          | 29.18bc              | 13.37abc        | 4.26cde           | 13.77ab         | 27.77a-d                |
| G 02 x 7           | 7.26a        | 0.72abc         | 32.82ab              | 14.33abc        | 4.47abc           | 13.33ab         | 28.00a-d                |
| MR 12 x MAL 04     | 7.36a        | 0.76a           | 29.94bc              | 15.42a          | 4.34a-d           | 13.66ab         | 31.33ab                 |
| MAL 3 x CY 4       | 5.12b        | 0.70abc         | 25.19c               | 14.70abc        | 4.22de            | 14.77ab         | 25.05cd                 |
| MAL 01 x 4         | 7.27a        | 0.75a           | 37.85a               | 15.11ab         | 4.52ab            | 13.88ab         | 33.89cd                 |
| MAL 8 x MAL 01     | 6.15ab       | 0.73ab          | 30.10b               | 13.17bc         | 4.43a-d           | 15.11ab         | 28.11a-d                |
| CY 15 x MAL 03     | 6.14ab       | 0.73ab          | 30.75b               | 14.49abc        | 4.34a-d           | 13.89ab         | 26.72bcd                |
| B 11 x 11          | 5.04b        | 0.68c           | 28.00bc              | 12.96c           | 4.20e             | 13.55b          | 24.66d                  |
| Average            | 6.64         | 0.73            | 30.22                | 14.26           | 4.38              | 14.22           | 27.97                   |
| CV (%)             | 17.29        | 3.68            | 10.03                | 8.45            | 2.79              | 6.40            | 9.76                    |

The number followed by the same letter is not significantly different at the 5% level according to the Duncan test.

The results of the analysis of the results of tons per hectare that are significantly different, this shows that in planting 70 x 20 cm each line gives optimal results according to the ability of plants to yield. With these plant spacing, each plant can improve optimal individual growth, so that the level of sunlight and nutrient competition in the soil is low and gives optimal seed yield according to its ability. Sparse spacing (low population) of plants will improve individual growth, but wide spacing will not only reduce plant populations but also result in reduced utilization of sunlight and nutrients by plants, because some of the light will fall to the soil surface and nutrients will be lost causing evaporation and washing (Yulisma, 2011). The highest yield was AMB 07xCML 161 (9.74 t/ha) and the lowest was MR 12 x MAL 04 (4.99 t/ha) (Table 4).

Seed yield analysis results that are not significantly different, this shows with a spacing of 70 x 20 cm gives a high seed yield according to the ability of plants to produce seed yield. Seed yields ranged from 0.73 to 0.76% (Table 4). The weight of 100 seeds, the length of the cob and the diameter of the cob the results of the analysis were significantly different, this shows that the spacing of 70 x 20 cm significantly affected these parameters, but did not significantly affect the number of rows per cob and number of seeds in the row. The weight of 100 seeds can also be influenced by genotype/strain and environmental factors, namely the high plant population tying competition between plants is higher so that it affects the size of the seeds [27–30]. The highest 100 seeds weight G 02 x 7 (38.46 g) and the smallest MR 12 x MAL 04 (24.42 g), the highest cob length MAL 01 x 4 (16.62 cm) and the smallest MR 12 x MAL 04 (13.85 cm), the biggest cob diameter is G 02 x 7 (4.42 cm) and the smallest is MR 12 x MAL 04 (4.00 cm), the largest number of rows is 1044-9 x 1027-11 (14.44 lines) and the smallest G 02 x 7 (12.89 rows), and the largest number of seeds in rows AMB 07 x CML 161 (33.33 seeds) and the smallest MR 12 x MAL 04 (28.50 seeds) (Table 4).
Table 4. Average yields and components of shade resistant lines at 70 x 20 cm spacing (population 71,428 plants/ha). Maros, 2016.

| Genotipes          | Yield (t / ha) | Yield (%) | Weight 100 seeds (g) | Cob length (cm) | Cob diameter (cm) | Number of rows | Number of seeds in a row |
|--------------------|----------------|-----------|----------------------|-----------------|-------------------|----------------|-------------------------|
| 1044-9 x 1027-11   | 7.74ab         | 0.73a     | 31.36cd              | 16.48a          | 4.35ab            | 14.44a         | 33.11a                  |
| AMB 07xCML 161     | 9.74a          | 0.75a     | 33.11a               | 15.30ab         | 4.34ab            | 14.11a         | 33.33a                  |
| G 02 x 5           | 8.77a          | 0.76a     | 34.11abc             | 16.60a          | 4.42a             | 13.89a         | 32.17a                  |
| G 02 x 7           | 7.49ab         | 0.74a     | 38.46a               | 15.04ab         | 4.20b             | 12.89a         | 29.89a                  |
| MR 12 x MAL 04     | 4.99b          | 0.72a     | 24.42e               | 13.85b          | 4.00c             | 13.44a         | 28.50a                  |
| MAL 3 x CY 4       | 6.80ab         | 0.73a     | 28.25cde             | 16.37a          | 4.17bc            | 13.55a         | 30.11a                  |
| MAL 01 x 4         | 8.33ab         | 0.74a     | 37.78ab              | 16.62a          | 4.32ab            | 13.66a         | 30.55a                  |
| MAL 8 x MAL 01     | 9.22a          | 0.77a     | 31.03cd              | 14.79ab         | 4.22b             | 14.33a         | 31.44a                  |
| CY 15 x MAL 03     | 10.07a         | 0.80a     | 31.03cd              | 14.66ab         | 4.32ab            | 14.22a         | 31.89a                  |
| B 11 x 11          | 6.81ab         | 0.73a     | 32.55bcd             | 16.11a          | 4.25ab            | 12.88a         | 31.50a                  |
| **Average**        | 7.99           | 0.74      | 31.92                | 15.58           | 4.26              | 13.74          | 31.25                   |
| **CV (%)**         | 26.27          | 7.41      | 10.74                | 7.51            | 2.63              | 7.94           | 9.08                    |

The number followed by the same letter is not significantly different at the 5% level according to the Duncan test.

4. Conclusion
Shade resistant genotypes significantly affected by plant spacing in the growth phase parameters, the higher the plant population the parameter values tend to increase, this is due to the level of sunlight and nutrient competition in the soil. Shade-resistant genotypes significantly affect plant spacing in yield components (t/ha), in general, the higher the population, the lower the yield and the percentage of yield decrease (t/ha) (decreasing the size of cob and seeds) depending on the type of strain. The highest yield (t/ha) at 70 x 15 cm plant spacing was tolerant genotype 1044-9 x 1027-11 (7.75 t/ha) and the highest yield at 70 x 20 cm plant spacing was CY 15 x MAL 03 (10.07 t/ha).

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