مجلة العلوم البحتة والتطبيقية
Journal of Pure & Applied Sciences
www.Suj.sebhau.edu.ly ISSN 2521-9200
Received 29/07/2020 Revised 05/12/2020 Published online 07/12/2020

Influence of Plant Population Density on Grain Yield and Yield Components of Three Different Maize Varieties (*Zea mays* L.) Under the Libyan West Coast Conditions.

Mohamed Rida Aboushagor , Hasan Mohamed Alharari, Saleh Mohamed Elmezoghi and *Khaled Al-Akhdhar Aisawi
Department of Crop Science,Faculty of Agriculture, University of Tripoli,Libya
*Corresponding author: k.aisawi@uot.edu.ly

Abstract A field experiment was conducted during 2007-2008 season at the experimental station of the Faculty of Agriculture, University of Tripoli to investigate the influence of different plant population densities namely: 30000, 40000, 50000, 60000 and 70000 plant ha^{-1} on two hybrids of maize namely: Geza-3060 and Geza-3084 introduced from the Arab Republic of Egypt and a local variety. Split plot design in Latin square with three replications was implemented. Main plots were assigned to the genotypes, subplots to plant population treatments. In general, results showed that maximum grain yield was obtained at 70000 plant ha^{-1} (8.28 ton ha^{-1}) on average of the three varieties which was not significantly different when planting at the rate of 50000 plant ha^{-1} ,this could result in reducing seed cost. Giza-3062 out yielded Giza-3084 and the local variety on average of different population densities by 3.82 and 4.49 ton ha^{-1} which corresponded to 71.4% and 96.0% respectively. Number of grains per ear and the average 100 grain weight were not contribute to high grain yield, but the number of ears was responsible to high grain yield across different plant population densities. To achieve high grain yield with low cost farmers should use hybrid maize varieties at a 50000 plant ha^{-1}.
Keywords: Plant population density, Hybrid Maize, Grain yield and yield components of maize.

تأثير الكثافة النباتية على الإنتاجية ومكوناتها لثلاثة أصناف من الذرة الصفراء (*Zea mays* L.) تحت ظروف الساحل الغربي الليبية

محمد رضا محمد أبوشاقور و حسن محمد الحراري و صالح محمد المزوغي و *خالد الأخضر العيساوي
قسم المحاصيل–كلية الزراعة–جامعة طرابلس، ليبيا
*للمراسلة: k.aisawi@uot.edu.ly

الملخص أجريت تجربة حقلية في محطة أبحاث كلية الزراعة بجامعة طرابلس خلال الموسم الزراعي 2007–2008 بغرض دراسة تأثير الكثافة النباتية: 30000، 40000، 50000، 60000 و 70000 نبات بالهكتار على صنفين من الذرة الصفراء هما: جيزا – 3060 و جيزا – 3084 أستوردت من جمهورية مصر العربية مقارنة مع الصنف المحلي. طبق تصميم القطع المنشقة في المربع اللاتيني بثلاثة مكررات، حيث وزعت الأصناف على القطع الرئيسية ووزعت الكثافات النباتية على القطع الثانوية. أظهرت النتائج أن أعلى إنتاجية للحبوب (8.28 طن للهكتار) قد تم تحقيقها تحت الكثافة النباتية 70000 نبات للهكتار. لم تختلف هذه الإنتاجية عن التي تم تحقيقها تحت الكثافة النباتية 50000 نبات للهكتار. لقد تفوق الصنف جيزا – 3060 على الصنف جيزا – 3084 و الصنف المحلي في متوسط الإنتاجية بصفة عامة بكمية 3.82 و 4.49 طن للهكتار وهي ما يساوي 71.4 و 96.0% على التوالي. لم يكن لصفتي عدد الحبوب بالكوز أو متوسط وزن الحبة أي مساهمة معنوية في الإنتاجية العالية، أما صفة عدد الكيزان بالمتر المربع فقد كان المكون الفسيولوجي الذي يفسر الزيادة في القدرة الإنتاجية في كل الكثافات النباتية المستعملة. توصي الدراسة بأنه للحصول على أعلى قدرة إنتاجية من حاصل الحبوب في الذرة الصفراء مع الأخذ في الاعتبار تكلفة البذور، فإنه ينصح بالزراعة على كثافة نباتية 50000 نبات بالهكتار.
الكلمات المفتاحية: الإنتاجية ومكوناتها، الكثافة النباتية، هجن الذرة الصفراء.

Introduction

Maize is an agronomic crop mostly affected by number of plant population density, which ultimately influences grain yield as well as other important agronomic traits. At low plant densities, many modern maize hybrids usually produce just one ear per plant, unlike other crops as wheat and barley, which produce more tillers and ears to compensate for low plant population density [4]. It was indicated that the use of high plant population in maize increases the interplant competition for light, water and nutrients and consequently, the final yield decreases due to the stimulation of apical dominance, induce barrens, and ultimately decreases the number of ears produced per plant and grains per ear [11]. Maize grain yield declines when plant density increases beyond the optimum plant density due to the low harvest index [12]. For maximum economic grain yield, maize population varies between 30000 to over 90000 plant ha^{-1} [10]. It was found in an evaluated five different population densities (56000, 65000, 73000, 81000 and 90000 plant ha^{-1}) of maize in Michigan, USA that the highest grain yield was obtained at 90000 plant ha^{-1} [13]. Factors as variety maturity, length of growing season, time of planting, water availability and raw spacing affected greatly the choice of an optimum plant population density [1] and [9]. Maize yield development is a series process in which the potential ear number is determined first followed by the number of grains per ear and by grain size. High plant population density makes plants produce non-viable ears because of a delay in ear differentiation and growth of ear primordial [9]. The delay in ear initiation with respect to high plant population density reduces number of kernels per ear through effects on developing ears before anthesis, pollination and fertilization, and during early stages of grain filling. High plant density may reduce the supply of nutrients such as nitrogen, photosynthesis and water to the growing ears that affect the number of differentiated spikelets that are fertilized [7]. The influence of high plant population density with respect to reduction of the final weight of grains can be explained by the differences in the initial size of spikelets during different phases of grain growth [6].

The present study was initiated to evaluate different plant population density of three varieties of maize on grain yield and yield components under the Libyan west coast environmental conditions.

MATERIALS AND METHODS

A field trial was conducted during 2007-2008 season at the experimental station of the Faculty of Agriculture, University of Tripoli to evaluate the effect of five plant population densities, namely 30000, 40000, 50000, 60000 and 70000 plant ha^{-1} on two hybrids of maize namely: Geza-3060 and Geza-3084 introduced from the Arab Republic of Egypt and a local variety. The experiment was designed as a Latin square design with respect to main plots (varieties) and plant population densities were arranged as sub-plots within each main plot. Varieties; Giza-3084 (V1), Giza-3062 (V2) and Local variety (V3), Plant population densities; PD1, PD2, PD3, PD4, and PD5 (represent 30000, 40000, 50000 60000 and 70000 plant ha^{-1}) respectively. Seeds were treated with a fungicide (Vitavax) prior to planting at a rate of 0.05%. Plot size was 2x3 m^2 with 60 cm between rows within each plot. The distance of 23, 27, 33, 42 and 60 cm were corresponded to the assigned plant populations respectively. Di-ammonium phosphate (18-46-0) at the rate of 100 kg ha^{-1} was applied at planting time. In addition Urea fertilizer (46% N) at a rate of 150 kg ha^{-1} was applied at two occasions, namely; at the 6th leaf was developed and at the beginning of anthesis. All necessary cultural practices such as irrigation and removal of weeds were performed periodically as required. By July the 30th the crop reached maturity and five plants were sampled at random for determination of grain yield and yield components growth. Data were analyzed statistically using a General Linear Model procedure in a statistical software (Minitab version 14). Partitioning the degrees of freedom for varieties and population densities were shown in (Table 1). P-values from analysis of variance were used to provide an indication of significance, and a Duncan's multiple range test was performed for comparing means.

Table 1. Partitioning the degrees of freedom (DF) of the experiment

Source of Variation	Symbol	DF
Total	c x c x p-1	44
Variety (var.)	c-1	2
Raw (c)	c-1	2
Column (c)	c-1	2
Error A	(c-1) (c-2)	2
Plant density (PD)	P-1	4
Var. x PD	(c-1) (P-1)	8
Error B	c (c-1) (P-1)	24

RESULTS AND DISCUSSION

Results showed that the interaction between plant population density and variety was not significant for all agronomic traits, suggesting that varieties respond similarly across the range of plant density. Grain yield was significantly affected and positively correlated with plant densities (Table 2 and figure 1). The maximum grain yield (8.28 ton ha^{-1}) was obtained under the highest plant population density 70000 plant ha^{-1} which was not significantly different from planting at the rate of 50000 plant ha^{-1}. The table also revealed that varieties differ significantly in grain yield.

Table 2. Effect of plant density (*10^3 ha.$^{-1}$) on grain yield (t. ha.$^{-1}$) among varieties.

Plant density / Variety	30	40	50	60	70	Mean
Giza 3062	4.28	7.78	12.93	9.81	11.07	9.17 ^{A}
Giza 3084	3.74	3.94	5.88	4.34	8.85	5.35 ^{B}
Local Variety	3.93	5.47	5.59	3.51	4.91	4.68 ^{B}
Mean	3.98 ^{c}	5.73 ^{b}	8.13^{a}	5.89 ^{b}	8.28^{a}	

Means followed by the same letter are not significantly different at 0.05 level based on Duncan's multiple range test.

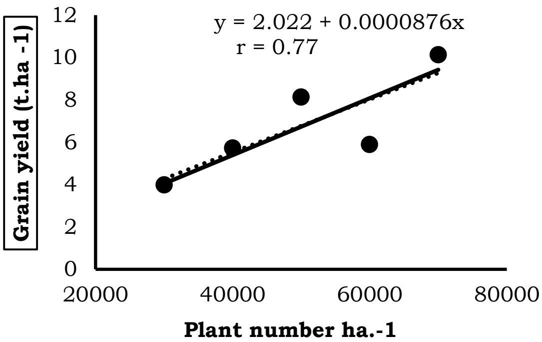

Figure 1. Grain yield

Giza 3062 hybrid produced the highest grain yield (9.17 ton ha^{-1}) which was statistically different from the other two varieties. These findings were in line with [3] who reported that a maximum grain yield in maize was achieved at 74000 plant ha^{-1}. Furthermore, It was found that the highest grain yield was obtained at final stand of approximately 90000 plant ha^{-1} [13]. Table 3. showed that the ear number m^{-2} was significantly different between different plant population densities. An increase of about 22.5% ears m^{-2} was achieved when population density increased from 60000 to 70000 plant ha^{-1}. Giza-3062 gave higher ear number m^{-2} than the other varieties.

Table 3. Effect of plant density (*10^3 ha^{-1}) on ear number m^{-2} among varieties.

Plant density / Variety	30	40	50	60	70	Mean
Giza 3062	3.96	7.33	10.01	9.61	10.52	8.29^{A}
Giza 3084	2.97	3.32	4.93	4.68	7.26	4.63^{B}
Local Variety	4.24	4.88	6.29	4.22	4.91	4.91^{B}
Mean	3.72^{c}	5.18^{b}	7.08^{a}	6.17^{b}	7.56^{a}	

Means followed by the same letter are not significantly different at 0.05 level based on Duncan's multiple range test.

Effects of plant population density on the grain number per ear was not significant (Table 4). This finding was not in agreement with [8] who reported that grain yield and grain number per ear increased with an increase in plant population densities. The hybrids Giza-3062 and Giza-3084 yielded on average 56 and 126 grain more than the local variety which account of an increase of 13.6 and 30.7% respectively.

Table 4. Effect of plant density (*10^3 $ha.^{-1}$) on grain number per ear among varieties.

Plant density / Variety	30	40	50	60	70	Mean
Giza 3062	398.0	477.7	533.6	476.3	449.5	467.0^{b}
Giza 3084	588.5	508.4	552.8	506.0	529.6	537.1^{a}
Local Variety	453.0	467.0	406.3	344.0	385.0	411.0^{c}
Mean	479.9	484.4	497.6	442.1	454.7	

Means followed by the same letter are not significantly different at 0.05 level based on Duncan's multiple range test.

Results showed that the varieties were not significantly different with respect to the average 100 grain weight under the plant population densities (Table 5).

The harvest index was not significantly different among different population plant density, however; the varieties showed a significant difference in harvest index. Giza-3062 and Giza-3084 hybrids were 14.5 and 48% lower in harvest index than the local variety respectively (Table 6).

Table 5. Effect of plant density (*10^3 $ha.^{-1}$) on 100 grain weight (gm.) among varieties.

Plant density / Variety	30	40	50	60	70	Mean
Giza 3062	26.0	22.0	24.3	20.7	24.3	23.5
Giza 3084	21.7	23.0	21.7	20.7	22.7	21.9
Local Variety	22.0	23.3	22.0	24.0	26.0	23.5
Mean	23.2	22.8	22.7	21.8	21.8	22.9

Means followed by the same letter are not significantly different at 0.05 level based on Duncan's multiple range test.

Table 6. Effect of plant density (*10^3 $ha.^{-1}$) on harvest index (%) among varieties.

Plant density / Variety	30	40	50	60	70	Mean
Giza 3062	20.35	28.19	31.47	26.46	33.83	28.05^{a}
Giza 3084	16.15	14.67	16.53	15.42	22.44	17.04^{b}
Local Variety	34.43	35.84	32.68	26.56	34.50	32.80^{a}
Mean	23.63	26.23	26.90	22.81	30.26	

Means followed by the same letter are not significantly different at 0.05 level based on Duncan's multiple range test.

The same results were obtained in plant height which was not affected by plant population density. However, varieties were significantly different and the hybrid Giza-3062 and Giza-3084 were taller than the local variety on average by 42 and 62 (cm) respectively (Table 7). However, it was indicated in some studies that plant height was increased with an increase of plant density [2].

Table 7. Effect of plant density (*10^3 $ha.^{-1}$) on plant height (cm.) among varieties.

Plant density / Variety	30	40	50	60	70	Mean
Giza 3062	172.5	185.0	193.6	186.1	183.6	184.2^{a}
Giza 3084	208.1	202.8	219.1	193.8	200.7	204.9^{a}
Local Variety	139.9	145.6	153.5	129.3	145.4	142.8^{b}
Mean	173.5	177.8	188.7	169.8	176.6	

Means followed by the same letter are not significantly different at 0.05 level based on Duncan's multiple range test.

References

[1]- Almeda, M. L., Merotto, J. R., and Sangoi, A. L. (2000), Incremento na densidade de plantas: uma alternative para mentar o rendimento de

graos de milho em regioes de curta stacao estival de crescimento. Ciecia Rural, Santa Maria., **30**, n.l, p.23-29.

[2]- Carena, M. J., and Cross, H. Z. (2000), Plant density and maize germplasm improvement in the northern corn belt. Mydica **48**,105-111.

[3]- Cox, W. J., and Otis, D. J. 1993, Grain and silage yield responses of commercial corn hybrids to plant densities.p.132. In Agronomy Abstracts 1993. ASA, Madison WI.

[4]- Gardner, F. P., Pearce, R. B., and Mitchell,R.L. 1985, Physiology of crop plants. Ames: Iowa State University. 327 p.

[5]- Jacobs, B. J., and Pearson, C. J., (1991), Potential yield of maize determined by rates of growth and development of ears. Field Crop Research., **27**, 281-298.

[6]- Jones, R. J., Roessler, J., and uattar, S., (1985), Thermal environment during endosperm cell division in maize: effects on number of endosperm cells and starch granules. Crop Science, Madison., **25**, N.4, p.830-834.

[7]- Lemcoff, J. H., and Loomis, R. S. (1994), Nitrogen and density influence on silk emergence, endosperm development, and grain yield of maize (*Zea mays L.*). Field Crops Research, Amesterdam., **38**, N.1, p.63-72.

[8]- Maddoni, G. A., Alfredo, G. C., and M.E. Otegui., (2006), Raw width and Maize grain yield. Agronomy Journal., **98**,1532-1543.

[9]- Matzenauer, R., Bergamaschi, H. and Berlato, M., (1998), Evaoptranspiracao da cultura de milho. I- efeito de epocas de semeadura. Revista Brasileira de Agrometeorologia, Santa Maria., **6**, N.1, p.9-14.

[10]- Olson, R. A., and Sander, D. H. 1988, Maize production. In: SPRAGUE, G.F. DUDLEY, J.W. Corn and corn improvement. Madison: American Society of Agronomy. Cap.11, p.639-686

[11]- Sangoi, L. and Salvador, R. J., (1998), Influence of plant height and leaf number on maize production at high plant densities. Pesquisa Agropecuaria Brasileira, Brasilia., **33** (3): 297-306.

[12]- Tollenaar, M., Aguhlera, A. and Nissanka, S. P., (1997), Grain yield is reduced more by weed interference in an old than in a new maize hybrid. Agronomy Journal, Madison, **89**, N.2, p.361-246.

[13]- Widdicombe, W. D., and Thelen, K. D., (2002), Row width and plant density effects on corn grain production in the northern Corn Belt. Agronomy Journal., **94**, 1020-1023.