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PRODUCTIVITY AND PHYSIOLOGICAL POTENTIALITY OF SOME SILAGE MAIZE GENOTYPES

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ABSTRACT: An experiment was conducted in the summer season of 2019 at the Agricultural Experiment Station, Faculty of Agriculture (El-Shatby), Alexandria University, Egypt. The main objectives of this study were: (i) to trace the physiological development of maize hybrids with reference to growth parameters, and (ii) to assess yield, quality and responses of silage maize genotypes to plant densities. Eight corn hybrids were used in this study, seven were single cross hybrids three of them were white-grain: SC10, SC128, SC131 and four yellow-grain SC166, SC167, SC168, SC176 and one white-grain three-way cross namely TWC321. Hybrids were developed by the Ministry of Agriculture, Maize Research Program, and Agriculture Research Center, Egypt. The fieldwork included two plant densities 20,000 and 35,000 plants faddan^{-1} *i.e.*; 47,619 and 83,333 plant hectare^{-1}, traits were measured at three development stages *i.e.* (35, 70 and 105 days after emergence). Spilt -plot design in a randomized complete block design, with three replications was employed. Sub-plot was 18 m^2 of six ridges each of 0.75 m width and four-meter long. Corn hybrids were distributed in the main–plots, whereas, the sub-plots contained the two plant densities. The results indicated that, as plant density increased from 47,619 to 83.333 plant hectare^{-1}, stalk diameter decreased from 24.53 to 20.91 mm, upper leaf chlorophyll content decreased from 46.45 to 42.01 SPAD, lower leaf chlorophyll content decreased from 36.74 to 31.31 SPAD, the no. of ears per plant decreased from 1.38 to 1.10 and plant dry weight decreased from 293 to 195 g plant^{-1}, respectively. Plant densities significantly gave similar plant dry weight after 35 days from emergence, while, low plant density (47.619 plant ha^{-1}) gave the heaviest plant dry weight after 70 and 105 DAE (279 and 584 g plant^{-1}, respectively).The results indicated that relative growth rate of maize hybrids during the first developmental stage (35-70 DAE) was significantly superior to measured figures in the late season stage (70-105 DAE). Also, hybrids with significantly higher RGR during the early season's stage were SC10, SC128, SC131 SC168 and SC176. While SC167 and TWC321 significantly exhibited lower values. By the late season stage (70-105 DAE) all hybrids had similar values of RGR. Effect of plant density on total dry forage yield over maize-hybrids and developmental stage, the highest significant total dry forage yield was recorded at a plant density of 83.333 plant hectare^{-1} (15.70 t. ha^{-1}), while, the plant density of 47,619 plant hectare^{-1} significantly recorded lower value (13.92 t. ha^{-1}). Maize hybrids were significantly divided into two groups regarding protein yield. A superior group with values 2.19, 1.96, 1.96, 1.61 and 1.84 t. ha^{-1} for SC10, SC131, SC168, SC128 and SC176. The second lower group included SC167, TWC321 and SC166 with values of (1.59, 1.45 and 1.20 t. ha^{-1} respectively).

Key words: Silage maize, plant densities, RGR, Chlorophyll, dry yield, quality.

INTRODUCTION

In Egypt, the major use of maize and sorghum production is grain production. However, also both are considered the main summer season's green fodder forage and silage crops. Other forages in the summer includes sudan grass, pearl millet and fodder cowpea. In the last few decades, maize became a major source of silage. Silage has become the main forage allowance in Egypt (Khamis *et al.*, 2019).

According to (McDonald *et al.*, 1991), corn silage is manufactured by controlled fermentation of plants at high moisture content. The process involves harvesting the entire plant biomass, chopping and compressing it in large piles. The suitability of corn for silage is due to its high dry

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matter production, high green yield per unit area, high energy content and quality of the biomass (Mandić *et al.,* 2013) and favorable quality characteristics suitable for animal production (Roth and Undersander, 1995).

Silage maize is a basic fodder for ruminants. During digestion the fiber content of the silage is transformed into volatile fatty acids, which are essential for milk production. In recent decades, both growers and breeders used to increase the fresh and dry matter yield of silage maize, besides maximizing the ear portion of total plant dry matter, good quality silage maize hybrids are considered to have the same quality characters as grain maize hybrids. Many farmers are still selecting for silage production and quality of maize hybrids based on grain yield quantities and qualities, but this may be not completely related to silage production and quality. In the future, it is expected that genetic improvement for silage will depend on stalk quality and ability for digestion (Deinum and Struik, 1989). The specific silage maize hybrids are selected based on fresh and dry matter yield, along with the percentage of ears. The metabolizable energy content of the forage, which is now must be tested during registration practice of the new cultivars, means that testing chemical quality and digestibility is becoming important traits, but is still not common (Khamis *et al.,* 2019) .

Farmers in Egypt used to grow corn for silage production from seeds of open-pollinated varieties. Recently, however, new silage hybrids with high biomass yields and high energy content have been introduced (Statistical year book, Ministry of Agriculture, 2019). The nutritional value of silage, (protein and carbohydrate contents) could vary among varieties, the nutritive values estimates for good quality corn silage were; 28-35 % dry matter, 7-8% protein, 38-45% NDF, 23-28 % ADF and 3.5 % fat (Mahanna, 2000).

Beside the suitable genetic material, practices maximizing corn productivity per unit area are essential. Corn hybrids grown under high plant density than that currently used could be beneficial (Al-Naggar *et al.,* 2016). Many studies recommended the increase of plant population density of silage corn by 10 to 20 % compared to corn harvested for grain yield (Hunter, 1986 and Cox, 1997). Although increasing plant densities tends to decrease stem diameter and increase the potential for stem lodging, this is much less an issue with silage corn than grain yield because silage is harvested much earlier (Jeschke *et al.,* 2008). (Ferreira *et al.,* 2014) indicated that a greater silage yield can be obtained from corn under a high planting population without a shortage of its nutritional composition. The main objectives of the present study were: (I) to trace the physiological development of maize hybrids with reference to growth parameters, and (II) to assess yield, quality and responses of maize genotypes for silage to plant densities.

MATERIAL AND METHODS

Plant Material & Treatments

The present study was conducted in summer seasons of 2019 at the Agricultural Experiment Station, Faculty of Agriculture (El-Shatby), Alexandria University.

Corn Hybrids

Eight corn hybrids were used in this study. Seven were single cross hybrids three of them were white: SC10, SC128, SC131 and four yellow SC166, SC167, SC168, SC176 and one white three - way cross (TWC) hybrid namely TWC321. Hybrids were developed by Ministry of Agriculture, Maize Research Program, Agriculture Research Center, Egypt.

Plant population's density

Tow plant densities were used in this study: 20,000 and 35,000 plants faddan^{-1} *i.e.*; (47,619 and 83,333 plants hectare^{-1}, respectively).

Plot Setup and Planting

The planting date was 23rd, April, 2019. A spilt -plot was used in a randomized complete block design (RCBD), with three replications. Sub - plot size was 18 m^2 with six ridges of 0.75 m width and four-meter long. Corn hybrids were distributed in the main – plots, whereas, the sub-plots contained plant densities. Seeding was done manually on one side of the ridge in hills with two - three grains per hill. Hill spacing was 16 and 28 cm apart for the two designed plant densities 83,333 and 47,619 plants hectare^{-1}, respectively. After emergence, plants were hand thinned to one plant per hill after three weeks from emergency. Irrigation was applied every 14-15 days using surface irrigation methods. Nitrogen in the form of urea (46.5% nitrogen N) was applied at the rate of 120 kg N. faddan^{-1} in two equal doses, the first was applied at the second irrigation, and the second was with the third irrigation. Weeds were controlled with a pre-emergence application of Stomp 50% at the rate of 1.5 Liter faddan^{-1}. Hand - hoeing was also performed twice during the growing season to eliminate germinated weeds. Insects were controlled using Chloropyriphose 48% EC, and Lante 90% SP.

Description of studied plant traits

Traits were measured on five guarded plants from each sub-plot at three development stages *i.e.* (35, 70 and 105 days after emergence). Those traits were:

I. Plant characters

1. Plant height

Plants were measured from the soil surface to the tip of the flag leaf (cm).

2. Stalk diameter

Corn stalk diameter was measured at the third internode above the brace roots with an electronic digital caliper (mm).

3. Number of leaves plant^{-1}

Leaves number were counted on the plants in one meter of each plots.

4. Leaf chlorophyll content

Leaf chlorophyll content was recorded using a portable SPAD meter Model SPAD-502; Minolta crop, Ramsey, NJ, USA as an indirect indicator of crop N status (Çarpıcı *et al.,* 2017). Where, the SPAD measures the difference between sending a red light (650 n.m.) and infrared light (940 n.m.) through the paper, generating a three digit SPAD value (Uddling *et al.*, 2007).

4.1. Upper leaf chlorophyll content

Three plants in the two middle rows of each plot were tagged and, on each plant, the top leaves were measured primary the eighth.

4.2. Lower leaf chlorophyll content

From the same plants in the two middle rows of each plot were tagged and, on each plant, the bottom leaves were measured.

5. Number of ears plant^{-1}

It was obtained by dividing the total number of ears by the number of plants in one meter of the ridge.

6. Plant dry weight

Determined as weighted mean of plant botanical components and dry matter percentage in each sub-plot.

Plant dry weight =
Plant fresh weight × (plant DM % / 100)

II. Above-ground botanical composition

Plant samples were harvested from a one-meter length from each sub-plot by cutting to 10 cm above the soil surface at the development stage 35, 70 and 105 days after emergence to determinate leaves/stem ratio, leaves dry matter % and stem dry matter % and at the development stages 70 and 105 days after emergence, to measure ears dry matter % and husks dry matter % as follow:

1. Leaves/stem ratio

Leaves/stem ratio = (leaves fresh weight/ stem fresh weight).

2. Dry matter partitioning

To calculate the dry matter of each component of the maize plants, a random sample was taken from leaves, stems, ears and husks of one-meter length from each sub-plot, weighed then oven dried at 60°C for 24 hours according to, (A.O.A.C., 1990) and presented as percent of dry fresh weight of each component as follow:

2.1. Leaves dry matter %

Estimated by taken a random sample of fresh leaves approximately (250 gram).

$$\text{Leaves DM \%} = \frac{\text{leaves dry weight}}{\text{leaves fresh weight}} \times 100$$

2.2. Stem dry matter %

Estimated by taken a random sample of fresh stem approximately (500 gram).

$$\text{Stems DM \%} = \frac{\text{stems dry weight}}{\text{stems fresh weight}} \times 100$$

2.3. Ears dry matter %

Estimated by taken a random sample (three ears per plot).

$$\text{Cob-grain DM \%} = \frac{\text{ears dry weight}}{\text{ears fresh weight}} \times 100$$

2.4. Husks dry matter %

Estimated by taken a random sample (three ears per plot).

$$\text{Husks DM\%} = \frac{\text{husks dry weight}}{\text{husks fresh weight}} \times 100$$

III. Growth parameters

Sampling for growth analysis traits used plant samples from sub-plot at the age of 35, 70 and 105 days after emergence to determine the following parameters:

1. Relative growth rate (RGR)

$$RGR = \left(\frac{\ln w2 - \ln w1}{t2 - t1}\right) \quad g\ g^{-1}\ t^{-1}$$

Where, "w_1" is the total dry weight at time "t_1", "w_2" is total dry weight at time "t_2", and "ln" is the natural logarithm according to (Tajul *et al.*, 2013).

2. Crop growth rate (CGR)

$$CGR = \frac{1}{GA}\left(\frac{W2 - W1}{t2 - t1}\right) \quad g\ m^{-2}\ t^{-1}$$

Where, "G_A" is ground area, "w_1" is total dry weight at time "t_1" and "w_2" is the total dry weight at time "t_2" according to (Tajul *et al.*, 2013).

3. Leaf area index (LAI)

Ear leaf area (LA) in cm^2, estimated by measuring ear leaf length (cm) x maximum leaf width (cm) x 0.75 as described by (Stickler, 1964), then used for calculating the leaf area/plant = Ear leaf area × No. of leaves $plant^{-1}$.

For leaf area index (LAI), it was estimate from the following formula:

$$LAI = \frac{1}{GA}\left(\frac{LA2 + LA1}{2}\right) \quad m^2\ m^{-2}$$

Where, "G_A" is ground area, "LA_1" is the leaf area at time "T_1" and "LA_2" is the leaf area at time "T_2" according to (Gardner *et al.*, 1985).

IV. Yield and quality traits

Total dry forage yield determined at the development stage 35, 70 and105 days after emergence. Protein yield determined at the development stage 105 days after emergence, where, representative samples of plant parts from each sub-plot were dried, ground in a mill and sieved with 1 mm mesh size sieve, mixed samples of leaves, stalks, husks and ears were analyzed for nitrogen content %.

1. Total dry forage yield (t. ha^{-1})

It was calculated by using the following formula:

Total dry forage yield =
mean dry weight/plant × plant density/ha.

2. Protein yield ha^{-1}

Protein yield ha^{-1} (ton) =
dry yield (ton) x crude protein content (%).

Where, crude protein content (%) was determined by multiplying nitrogen content (%) × 6.25 according to (A. O. A. C., 1990).

Statistical analysis

Differences in plant characters, botanical composition, growth parameters and yield and quality were subjected to Analysis of variance (MSTAT Development Team, 1989). The least significance difference test (LSD) was used to compare mean values of each attribute according to (Snedecor and Cochran, 1980).

RUSULTS AND DISCUSSION

I. Plant characters

The studied plant characters under two plant densities at each of three developmental stages *i.e.*; 35, 70 and 105 days after emergence were plant height, stalk diameter, number of leaves plant^{-1}, upper leaf chlorophyll content, lower leaf chlorophyll content and plant dry weight however, number of ears plant^{-1} was measured at 70 and 105 days after emergence.

The effects of developmental stages on plant characters for the maize-hybrids were presented in Table 1. Plant height and dry weight were significantly ascending with progress of developmental stages (65.58, 230.71 and 258.01 cm and 15, 242 and 474 g plant^{-1} for 35, 70 and 105 DAE, respectively). However, Lower leaf chlorophyll content exhibited opposite manner, since, the least value was obtained with late season stage. (47.97, 35.00 and 19.12 SPAD for 35 ,70 ,105 days, respectively). Number of leaves was significantly maximum after 70 days from emergence (15.48 leaves plant^{-1}), while, significantly lower value was recorded at early stage (10.02 leaves plant $^{-1}$). Number of ears plant^{-1} was significantly maximum after 70 DAE (1.34 ears plant^{-1}). Meanwhile, significantly lower value was recorded at later stage (1.15 ears plant $^{-1}$). With regard to plant height, maize hybrids could be divided to two groups; superior group with values ranged between180.83 to 198.88 cm and indicated, SC168, SC131, SC176, TWC321, SC128 and SC10. A group of moderate values ranged between 169.06 and 180.88 cm and included SC166, SC167 and SC168. Stalk diameter of the studied maize hybrids grouped in two groups. Thick stalked hybrids (22.24 to 24.66 mm), included SC166, SC128, TWC321, SC167, SC 10 and SC131. A thin stalked hybrid from 20.32 to 22.24 mm included SC166, SC168, and SC176.

The hybrid TWC321 significantly exhibited dense leaves (14.34 leaves plant^{-1}). SC10 came in the second rank with 14.18 leaves plant^{-1}, whereas, SC 128 and SC131 significantly showed moderate number of leaves plant^{-1} (13.59 and 13.56 leaves, respectively). SC166 significantly had low number of leaves (13.37 leaves plant^{-1}). SC167 and SC176 showed the least number of leaves (12.98 and 12.92, respectively). Concerning upper leaf chlorophyll content (SPAD), SC167, SC168 and SC166 and SC10 showed the highest SPAD value (48.80, 47.25, 45.67 and 43.40, respectively). The least SPAD value recorded for the other studied hybrids, ranged between 41.72 to 42.66 SPAD. Lower leaf chlorophyll content (SPAD) was significantly similar among all hybrids expect for, SC176 and SC128 that gave significantly lower values. Maize hybrids were significantly divided to two groups regarding number of ears plant^{-1}. A high eared group with values between 1.23, 1.45 to 1.53 ears plants^{-1} and included for SC10, SC168, SC167 and SC166. A group of moderate earing capacity with value between1.04 and 1.23 ears plant^{-1} that included TWC321, SC128, SC131 and SC176. In general, SC131 exhibited thick stalk (24.66 mm), high number of leaves plant^{-1} (13.56 leaves) and moderate number of ears plant^{-1} (1.11 ears). SC167 showed thick stalk diameter (23.30 mm) and superiority in number of ears plant^{-1} (1.53 ears) and upper leaf chlorophyll content (48.80 SPAD). On the other hand, TWC321 showed higher number of leaves plant^{-1}(14.34 leaves), thick stalk diameter (22.45 mm) and the least number of ears plant^{-1}(1.04 ears).

The effect of plant density on plant characters over maize-hybrids was presented in Table 1. As plant density increased from 47,619 to 83.333 plant hectare^{-1}, stalk diameter decreased from 24.53 to 20.91 mm, upper leaf chlorophyll content decreased from 46.45 to 42.01 SPAD, lower leaf chlorophyll content decreased from 36.74 to 31.31 SPAD, number of ears per plant decreased from 1.38 to 1.10 and plant dry weight decreased from 293 to 195 g plant^{-1}, respectively.

The interaction between development stages and plant densities for plant dry weight of maize hybrids is showed in Table 2. The data revealed that, plant densities significantly gave similar plant dry weight after 35 days from emergence, while, low plant density (47.619 plant hectare^{-1}) gave the heaviest plant dry weight after 70 and 105 DAE (279 and 584 g plant^{-1}, respectively).

Table (1): Mean value of plant height, stalk diameter, no. of leaves plant^{-1}, upper leaf chlorophyll content, lower leaf chlorophyll content, no. of ears plant^{-1}, plant dry weight; and leaf/stem ratio and dry matter percentages of leaves, stem, ears and husks; and total dry forage yield (t. ha^{-1}) and protein yield (t. ha^{-1}) of maize hybrids as affected by plant densities over the development stages.

Treatment	Traits													
	Plant characters							Above-ground botanical composition					Yield and quality	
	Plant height (cm)	Stalk diameter (mm)	No. of leaves plant^{-1}	Upper leaf chlorophyll content (SPAD)	Lower leaf chlorophyll content (SPAD)	No. of ears plant^{-1}	Plant dry Weight (g)	Leaf/stem ratio	Leaves DM%	Stem DM%	Ears DM% ■	Husks DM% ■	Total dry forage yield (t. ha^{-1})	Protein yield (t. ha^{-1})
Development stages														
35 days	65.58^{c*}	22.97	10.02^{c}	43.44	47.97^{a}	-	15^{c}	0.97^{a}	15.47^{c}	6.70^{c}	-	-	0.98^{c*}	-
70 days	230.71^{b}	23.21	15.48^{a}	44.96	35.00^{b}	1.34^{a}	242^{b}	0.42^{b}	29.56^{b}	16.20^{b}	12.98^{b}	18.51^{b}	14.34^{b}	-
105 days	258.01^{a}	21.99	15.05^{b}	44.28	19.12^{c}	1.15^{b}	474^{a}	0.42^{b}	37.64^{a}	20.37^{a}	60.30^{a}	44.27^{a}	28.99^{a}	-
L.S.D $_{(0.01)}$	13.63	N.S.	0.08	N.S.	4.35	0.08	51	0.21	1.65	1.32	1.62	1.85	3.53	-
Maize hybrids														
SC10	198.88^{a}	23.95^{a}	14.18^{b}	43.40^{a}	33.10^{a}	1.23^{ab}	288	0.60	27.21	15.18	37.12^{a}	31.89^{a}	17.40^{a}	2.19^{a}
SC128	193.16^{a}	22.92^{a}	13.59^{c}	41.72^{b}	30.62^{ab}	1.09^{b}	258	0.52	27.30	14.39	36.73^{a}	28.79^{b}	15.53^{a}	1.61^{a}
SC131	182.43^{a}	24.66^{a}	13.56^{c}	42.10^{b}	34.12^{a}	1.11^{b}	270	0.80	27.31	14.29	39.85^{a}	32.63^{a}	17.45^{a}	1.96^{a}
SC166	178.73^{b}	22.24^{ab}	13.37^{d}	45.67^{a}	34.08^{a}	1.45^{a}	202	0.53	26.72	13.20	34.44^{b}	30.10^{ab}	12.08^{b}	1.20^{b}
SC167	169.06^{b}	23.30^{a}	12.98^{f}	48.80^{a}	36.23^{a}	1.53^{a}	239	0.60	27.23	13.64	36.10^{ab}	34.25^{a}	14.63^{ab}	1.59^{ab}
SC168	180.83^{ab}	21.97^{b}	13.20^{e}	47.25^{a}	39.75^{a}	1.37^{a}	267	0.57	27.72	14.78	35.15^{b}	32.15^{a}	16.67^{a}	1.96^{a}
SC176	186.14^{a}	20.32^{b}	12.92^{f}	42.23^{b}	30.29^{b}	1.13^{b}	229	0.56	29.09	15.18	38.67^{a}	30.56^{a}	12.63^{b}	1.84^{a}
TWC321	188.94^{a}	22.45^{a}	14.34^{a}	42.66^{b}	34.01^{a}	1.04^{bc}	199	0.61	27.88	14.73	35.06^{b}	30.73^{a}	12.08^{b}	1.45^{b}
L.S.D $_{(0.05)}$	16.61	2.37	0.13	5.62	7.10	0.16	N.S.	N.S.	N.S.	N.S.	3.25	3.69	4.31	0.58
Plant density ha^{-1}														
47,619	186.90	24.53^{a}	13.59	46.45^{a}	36.74^{a}	1.38^{a}	293^{a}	0.65^{a}	27.57	14.28	37.03	31.01^{b}	13.92^{b}	1.72
83,333	182.64	20.91^{b}	13.45	42.01^{b}	31.31^{b}	1.10^{b}	195^{b}	0.55^{b}	27.54	14.56	36.25	31.76^{a}	15.70^{a}	1.73
L.S.D $_{(0.01)}$	N.S.	1.07	N.S.	3.04	4.27	0.08	35	0.08	N.S.	N.S.	N.S.	0.68	1.75	N.S.

■: means for two development stages (70 and 105 days) only. Protein yield determined at the development stage 105 days after emergence

*; Means followed by the same letter(s) are not significantly different at the same column according to LSD procedure.

Several authors showed variations in plant characters of maize genotypes El- Metwally *et al.,* (2011) showed that, SC10 was superiority in plant height and that result was supported by the finding of El-Shahed *et al.,* (2013) and Hegab *et al.,* (2019). On the other hand, Khan *et al.,* (2012), reported that plant height was not varied among the studied hybrids. Meanwhile, a progressive increase in plant height was obtained with progress of maize-plant development towards physiological maturity with variable rate depending on stage of growth Pandey *et al.,* (2000), Tajul *et al.,* (2013), Shaalan *et al.,* (2015), Kelly *et al.,* (2015) and Akinnuoye-Adelabu and Modi (2017). In the mean times, our results presented here for plant density effects on plant height were in harmony with the results of EL-Metwally *et al.,* (2011), El-Shahed *et al.,* (2013) and El-Sobky and El- Nagar (2016), since, their results showed that with increasing plant density, plant height was not affected. Similar results for this trait were reported by Turgut *et al.,* (2005), Carpici *et al.,* (2010), Baghdadi *et al.,* (2012), Karashin (2014), Kumar *et al.,* (2016). On the other hand, Mandic *et al.,* (2015), Rahuma and muhumed (2018), El-Hosary *et al.,* (2019), Fromme *et al.,* (2019) and Li *et al.,* (2019), reported that, plant height increased with increasing plant density, while, El-Mekser *et al.,* (2009) and Awadalla and morsy (2016), reported that, plant height decreased with increasing plant density.

Stalk diameter was reviewed similar among maize genotypes Yilmaz *et al.,* (2007), Lashkari *et al.,* (2011) and Awadalla and Morsy (2016). Meanwhile, Dekalp (DK) varieties exhibited thicker stalks Fromme *et al.,* (2019). In the meantime, stalk diameter increased with progress of maize-plant growth until stage 10 (V10;10th leaf collar unfolded = 70 days) then decreased with later progress to the sencence of basal leaves that has an attached sheath to the first intermodal area, Kelly *et al.,* (2015). Regarding the effect of plant density on stalk diameter Turgut *et al.,* (2005), Awadalla and morsy (2016), Mandic *et al.,* (2015), Fromme *et al.,* (2019) and Saberi (2019), reported results similar to what we have here since, they found that, stalk diameter decreased with increasing plant population density. On the other hand, Lashkari *et al.,* (2011), El-Shahed *et al.,* (2013) and El-Sobky and El- Nagar (2016), reported that, stalk diameter was not affected with increasing plant population density.

Number of leaves plant^{-1} varied among Egyptian maize hybrids as demonstrated by Awadalla and Morsy, (2016), El-Hosary *et al.,* (2019) and Hegab *et al.,* (2019). Also, international hybrids Mandic *et al.,* (2015), Nwokwu (2016) and Nazly *et al.,* (2019) reported similar results with other hybrid. Also, Akinnuoye-Adelabu and Modi, (2017), noticed an increase in number of leaves plant^{-1} with progress of plant development until 84 days from planting. Conversely, Hassan (2000), Mandic *et al.,* (2015), Awadalla and morsy (2016) showed that number of leaves plant^{-1} was not affected with increasing plant density. Turgut *et al.,* (2005) and Saberi (2019), noticed an increase in number of leaves plant^{-1} with increase plant density, while, number of leaves plant^{-1} decreased with the increase in plant density Carpici *et al.,* (2010), Kumar *et al.,* (2016) and El-Hosary *et al.,* (2019).

Table (2): Mean values of plant dry weight (g plant^{-1}) as affected by the interaction between densities × development stage.

Plant densities ha^{-1}	Development stage		
	35 days	70 days	105 days
47,619	17	276	584
83,333	14	207	365
L.S.D$_{(0.01)}$	49		

El Gizaw (2009), reported that, TWC351 recorded (38.8 SPAD) in the first season and (40 SPAD) in the second season. Leaf chlorophyll content (SPAD values) decreased with plant development towards maturity with maximum value after 60 days from sowing Tajul *et al.*, (2013) and Yan *et al.*, (2016). As for, plant population density effects, our results were in harmony with the results of Yao *et al.*, (2011), El-Sobky and El-Nagar (2016), Carpici *et al.*, (2016) and Yan *et al.*, (2016), who noticed a decreases in SPAD values with increasing plant population density.

Number of ears plant^{-1} was noticed similar among maize hybrids Turgut *et al.*, (2005) and Lashkari *et al.*, (2011). While, EL-Metwally *et al.*, (2011), found that SC122 showed the highest number of ears plant^{-1} (0.94 ears) versus TWC321 and SC10 that gave the least number of ears plant^{-1} (0.90 and 0.91 ears, respectively). Sangoi *et al.*, (2002), Mahgoub and El-Shenawy (2005), Abuzar *et al.*, (2011) and Dahmardeh (2011) found that, number of ears plant^{-1} decreased with increasing plant density. While, El Gizaw (2009), El-Sobky and El- Nagar (2016) and Rahuma and muhumed (2019), found that, with increased density from 24,000 to 34,000 plant fad^{-1}, number of ears plant^{-1} decreased from 1.20 to 1.04 ears.

Plant dry weight was recorded variable among maize genotypes Gaile (2008) and Islam *et al.*, (2019). Also, maize plant dry weight increased with growth progression, but, the rate of increase of dry weight was highest at 60 to 90 days after sowing, the results presented here were in agreement with results of Shaalan *et al.*, (2015), Koca and Erekul (2016) and Islam *et al.*, (2019). With increasing plant density, plant dry weight decreased and our results for this trait were in harmony with those of Karashin (2014) who found that increasing plant density from102,040 to 142,850 plant per hectare, plant dry weight decreased from (0.212 to 0.168 kg plant^{-1}). on the other hand, our results for this trait were not in harmony with the results of Saberi (2019) and Ferreira *et al.*, (2014), who reported that, increased plant density from 60,000 to 90,000 plant ha^{-1} increased plant dry weight as 0.265 to 0.650 kg plant^{-1}.

II. Above-ground botanical composition

The studied botanical composition of maize genotypes at each developmental stage for two plant densities included stem and leaf/stem ratio and dry matter DM percentages of leaves and stem; on the other hand, dry matter percentages of ears and husks were measured at the last two developmental stages (70 and 105 days after emergence). Effects of developmental stages on botanical composition of maize-hybrids were illustrated in Table 1. Dry matter percentages of leaves, stem, ears and husks were significantly ascending with progress of development stages (15.47, 29.56 and 37.64 % for leaves, 6.70, 16.20 and 20.37 % for stem, 12.98 and 60.30 % for ears and 18.51 and 44.27% for husks, respectively) for the four mentioned characters during stages 35, 70 and 105 DAE, respectively). Leaf/stem ratio exhibited opposite manner, since, the least values were obtained with progress of plant developmental stages (0.97, 0.42 and 0.42 for the three characters at 35, 70,105 DAE, respectively).

Regarding the response of botanical composition characters to hybrid variations Table 1, maize hybrids might be significantly divided to two distinct groups regarding percentage of ears DM. A superior group with values ranged between 36.10 and 39.85 % included SC167, SC128, SC10, SC176 and SC131. A group of moderate values ranged between 36.10 and 34.44% and included SC167, SC168, TWC321 and SC166. As for, percentage of husks DM, maize hybrids were significantly divided to two groups. A superior group with values between 30.10 and 34.25 %, included SC167, SC131, SC168, SC10, TWC321, SC176 and SC166. A group of moderate values between 28.79 and 30.10 %, that include SC166 and SC128. Concerning the effects of plant density on botanical composition of maize-hybrids Table 1, as plant density increased from 47,619 to 83.333 plant hectare^{-1}, percentage of husks DM increased from 31.01 to 31.76 %. While, leaf/stem ratio decreased from 0.65 to 0.55, respectively.

Results in Table 3 showed that, it was obvious that percentage of leaves dry matter, percentage of stem dry matter and percentage of ears dry matter were generally progressed with the progress of developmental stages. However, the best combination of plant density and genotype at 105 DAE was for leaves DM % under higher plant density for SC167 and TWC321 (41.37 and 41.93 %) and under lower density for SC176 (47.06%). As for stem DM % the best combination of plant density and genotype at 105 DAE under lower plant density for SC10 (26.29%) and under higher density for SC168 and SC176 (23.21 and 23.92 %, respectively). Ears DM % the best combination of plant density and genotype at 105 DAE under both lower and higher plant density for SC10, SC131 and SC176 (61.93, 61.95; 61.79, 64.20 and 62.32, 62.43 %).

Botanical composition traits of maize genotypes were illustrated and discussed by several investigators. As for, leaf/ stem ratio, Nazli *et al.*, (2019), reported that, leaf/stem ratio varied among all maize varieties. Baghdadi *et al.*, (2012), found that, as plant density increased from 90,000 to 130,000 plants ha^{-1} leaf/stem ratio decreased from 0.46 to 0.40. Dry matter percentages of leaves, stem and ears were recorded variable among maize genotypes Millner *et al.*, (1996), Islam *et al.*, (2019) and Nazli *et al.*, (2019). Also, percentage of leaves DM, percentage of stem DM, percentage of ears DM and percentage of husks DM increased with growth progression from emergence to maturity Koca and Erekul (2016) and Neumann *et al.*, (2020). According to Millner *et al.*, (1996), the percentage of leaves DM, percentage of stem DM was not affected with the increase in plant population density. While, percentage of ears DM and percentage of husks DM increased with increased plant population density Saberi, (2019).

Table (3): Mean values of percentage of leaves dry matter, percentage of stem dry matter and percentage of ears dry matter as affected by the interaction between maize hybrids × densities × development stages.

Maize hybrids	Densities	% leaves DM			% stem DM			% ears DM	
		Development stage							
		35 days	70 days	105 days	35 days	70 days	105 days	70 days	105 days
SC10	47,619	19.21	28.95	40.31	5.43	14.08	26.29	12.76	61.93
	83,333	13.86	26.90	34.01	8.42	18.49	18.35	11.83	61.95
SC128	47,619	12.74	33.31	37.95	5.04	17.30	20.65	17.46	55.75
	83,333	13.56	30.91	35.30	6.55	15.79	20.98	13.43	60.28
SC131	47,619	16.41	29.11	39.56	6.98	15.37	19.08	18.75	61.79
	83,333	15.26	27.79	35.75	7.83	15.26	21.19	14.66	64.20
SC166	47,619	11.46	31.25	33.67	6.89	16.19	17.62	12.27	60.05
	83,333	15.76	30.38	37.78	6.94	15.17	16.72	9.66	55.76
SC167	47,619	14.90	28.13	35.06	6.27	16.17	17.45	11.64	60.89
	83,333	15.51	28.40	41.37	6.71	15.99	19.25	11.41	60.47
SC168	47,619	17.07	29.62	36.00	7.19	16.31	19.06	11.25	60.56
	83,333	15.57	28.26	39.79	6.51	16.41	23.21	11.55	57.25
SC176	47,619	18.40	27.13	32.24	6.64	14.46	21.81	14.90	62.32
	83,333	17.18	32.53	47.06	6.64	17.60	23.92	15.03	62.43
TWC321	47,619	17.26	30.14	41.93	6.78	17.98	22.02	10.48	59.73
	83,333	13.40	30.17	34.39	6.75	16.59	18.26	10.61	59.43
L.S.D $_{(0.05)}$	-	6.43			3.97			3.68	

III. Growth parameters

Studied growth parameters included relative growth rate (RGR), crop growth rate (CGR) and leaf area index (LAI) during growth stages. The effect of developmental stages on growth parameters over maize-hybrids were presented in Table 4. Leaf area index (LAI) was significantly ascending with progress of development stages (4.41 and 6.09 m^2 m^{-2}, respectively) RGR exhibited opposite manner, since, the least value was obtained with late season stage (0.538 and 0.145 g g^{-1} $week^{-1}$ for 35-70 and 70-105 days, respectively).

Means of growth parameters of maize hybrids over plant densities and developmental stage were illustrated in Table 4. Results divided hybrids with respect to LAI to two groups. The first group with high LAI (4.97, 5.06, 5.11, 5.49, 5.68 and 5.94 m^2 m^{-2}) for SC176, SC168, SC166, SC10, SC128 and SC131. The second group with lower LAI reaching 4.86, 4.88 and 4.97 m^2 m^{-2} for SC167, TWC321 and SC176, respectively. Effect of plant density on growth parameters over developmental stages and maize hybrids Table 4. Showed that, the highest LAI was recorded with plant density of 83.333 plant $hectare^{-1}$ (6.39 m^2 m^{-2}), while plant density of 47,619 plant $hectare^{-1}$ gave lower value of 4.11 m^2 m^{-2}.

Table (4): Mean values of relative growth rate, crop growth rate (g m^{-2} $week^{-1}$) and leaf area index (m^2 m^{-2}) of maize hybrids as affected by plant densities over the development stages.

Treatment	Traits		
	RGR (g g^{-1} $week^{-1}$)	**CGR (g m^{-2} $week^{-1}$)**	**LAI (m^2 m^{-2})**
Development stage (DAE)			
35-70 days	0.538[a*]	267.35	4.41 [b]
70-105 days	0.145[b]	290.84	6.09 [a]
L.S.D $_{(0.01)}$	0.031	N.S.	0.49
Maize hybrids			
SC10	0.349	339.24	5.49 [a]
SC128	0.331	277.51	5.68 [a]
SC131	0.362	310.38	5.94 [a]
SC166	0.335	228.98	5.11 [a]
SC167	0.334	274.92	4.86 [b]
SC168	0.360	326.45	5.06 [a]
SC176	0.341	234.02	4.97 [ab]
TWC321	0.322	241.26	4.88 [b]
L.S.D $_{(0.05)}$	N.S.	N.S.	0.98
Plant density ha^{-1}			
47,619	0.352	266.78	4.11[b]
83,333	0.331	291.41	6.39[a]
L.S.D $_{(0.01)}$	N.S.	N.S.	0.49

*; Means followed by the same letter(s) are not significantly different according to LSD procedure.

The interaction between growth stage and maize hybrids for RGR was presented in Table 5. The results indicated that relative growth rate of maize hybrids during the first developmental stage (35-70 DAE) was significantly superior to measured figures in late season stage (70-105 DAE). Also, hybrids with significantly higher RGR during early seasons stage were SC10, SC128, SC131 SC168 and SC176. While, SC167 and TWC321 significantly exhibited lower values. By late season stage (70-105 DAE) all hybrids had similar values of RGR.

Our results for CGR were in harmony with the results of Pandey *et al.,* (2000) and Khan *et al.,* (2012), where, CGR was recorded variable among maize genotypes. Also, maize CGR increased up to 65 days after sowing (DAS) and then start declining Baghdadi *et al.,* (2012), Khan *et al.,* (2012) and Islam *et al.,* (2019). Declined RGR after 90 DAS, might due to after vegetative stage dry matter accumulation increases, but with lower rate of accumulation than at vegetative stage. CGR increased with increasing plant density Khalil *et al.,* (2010) and Baghdadi *et al.,* (2012). On the other hand, Tajul *et al.,* (2013), recorded that, CGR decreased with increasing plant population density from 53,000 to 80,000 plant ha^{-1}. While, Tajul *et al.,* (2013), reported a progressive decrease in RGR with progress of maize-plant development towards physiological maturity with variable rate depending on stage of growth. RGR increased progressively with time reaching peak during 65 DAS and decreased with plant development. The decrease in RGR was due to the increase of metabolically active tissue and decrease in net assimilation rate (NAR), with variations in RGR across genotypes were not apparent in the later growth period, but the differences were observed in the early growth period.

Awadalla and morsy, (2016), reported that, maize genotypes; SC162, SC168 and SC176 showed a similar leaf area index. On the other hand, LAI varied among Egyptian maize hybrids. EL-Metwally *et al.,* (2011), El-Shahed *et al.,* (2013) and Hegab *et al.,* (2019), illustrated that, SC10 gave the highest LAI (3.48 m^2 m^{-2}), whereas, TC 352 gave the least LAI (2.71 m^2 m^{-2}) Khan *et al.,* (2012) and Baghdadi *et al.,* (2012) noticed that, LAI progressively increased up to 65 DAS and then start declining. As plant density increased, leaf area index LAI increased according Kumar and Walia (2003), Bruns and Abbas (2006), Abuzar *et al.,* (2011), Khalil *et al.,* (2010), Baghdadi *et al.,* (2012), El-Shahed *et al.,* (2013), El-Hosary *et al.,* (2019) and Salifu and Dóka (2019). Also, with increased plant density from 20,000 to 30,000 plant. $faddan^{-1}$ gave an increase in LAI from 4.36 to 8.24 m^2 m^{-2} Rahuma, (2018).

Table (5): Mean values of relative growth rate (RGR) ($g\ g^{-1}\ week^{-1}$) as affected by the interaction between maize hybrids × development stages.

Maize hybrids	**RGR ($g\ g^{-1}\ week^{-1}$)**	
	Development stage	
	35-70 days	**70-105 days**
SC10	0.531	0.167
SC128	0.548	0.113
SC131	0.614	0.109
SC166	0.518	0.151
SC167	0.510	0.158
SC168	0.567	0.153
SC176	0.554	0.128
TWC321	0.464	0.179
L.S.D $_{(0.01)}$	0.087	

IV. Yield and quality

Total dry forage yield of maize hybrids was measured under two plant densities at 35, 70 and 105 days after emergence. However, protein yield was only measured after 105 days after emergence. Regarding the effect of developmental stages on total dry forage yield over maize-hybrids and plant density Table 1, values was significantly ascending with progress of development stages as 0.98, 14.34 and 28.99 t. ha^{-1} for 35 ,70 and 105 days after emergence, respectively.

Total dry forage yield of hybrids over development stages and plant density was divided to two groups. A superior group with value 17.45, 17.45, 16.67, 15.53 and 14.63 t. ha^{-1} for SC131, SC10, SC168, SC128, and SC167. A significantly lower total dry forage yield was recorded by SC166, SC167, SC176 and TWC321 (12.08, 14.63, 12.63 and 12.08 t. ha^{-1}, respectively). Maize hybrids were significantly divided to two groups regarding protein yield. A superior group with values 2.19, 1.96, 1.96, 1.61 and 1.84 t. ha^{-1} for SC10, SC131, SC168, SC128 and SC176. The second lower group included SC167, TWC321 and SC166 with values of 1.59, 1.45 and 1.20 t. ha^{-1}. Effect of plant density on total dry forage yield over maize-hybrids and developmental stage were shown in Table 1. The highest significant total dry forage yield was recorded at plant density of 83.333 plant hectare^{-1} (15.70 t. ha^{-1}), while, the plant density of 47,619 plant hectare^{-1} significantly recorded lower value (13.92 t. ha^{-1}).

Total dry forage yield was recorded variable among maize genotypes Millner *et al.*, (2005), Stanton *et al.*, (2007), Gaile (2008), Lynch *et al.*, (2012), and El-Hosary *et al.*, (2019). Meanwhile, a progressive increase in total dry forage yield was obtained with progress of maize-plant development towards physiological maturity with variable rate depending on stage of growth Cusicanqui and Lauer (1999). Shaalan *et al.*, (2015), found that, total dry forage yield, increased from 45 to 75 days after sowing (3.18 to 8.42 t. ha^{-1}, respectively). As plant population density increased, total dry forage yield increased Soto *et al.*, (2002), Widdicomble and Thelen (2002), Turgut *et al.*, (2005), Subedi *et al.*, (2006), Stanton *et al.*, (2007), Carpici *et al.*, (2010), Baghdadi *et al.*, (2012), Karashin (2014), Haddadi and Mohseni, (2016) and Opoku (2017). With increasing density from 64,200 to 88,900 plant ha^{-1}, total dry forage yield increased by 1.6 t. ha^{-1} Ferreira *et al.*, (2014).

Our results on protein yield were in harmony with the results of El-Hosary *et al.*, (2019), who noticed that, the highest protein yield of 0.79 t. ha^{-1} was obtained from maize hybrid SC2031. Babić *et al.*, (2018), found that, maize variety ZP620b and ZP 718b recorded high protein yields of 0.75 and 0.72 t. ha^{-1}, respectively. El-Hosary *et al.*, (2019), found that, with increasing plant density, protein yield decreased. While, Soto *et al.*, (2002), reported that, protein yield was not affected by plant density.

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الإنتاجية والقدرات الفسيولوجية لبعض الطرز الوراثية لذرة السيلاج

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الملخص العربى

أجريت تجربة حقلية خلال موسم صيف ٢٠١٩ بمحطة التجارب والبحوث الزراعية بكلية الزراعة (الشاطبي)، جامعة الإسكندرية. كانت الأهداف الرئيسية لهذه الدراسة هي: (١) تتبع تطور النمو الفسيولوجي لهجن الذرة الشامية للسيلاج تبعاً لمقاييس النمو ، و (٢) تقدير الإنتاجية والجودة والاستجابة الفسيولوجية لهجن السيلاج من الذرة الشامية للكثافة النباتية. هذا وقد شملت التجربة الحقلية علي ثمان هجن من الذرة الشامية، سبعة منها هجن فردية، ثلاثة منها بيضاء الحبوب (SC10، SC128، SC131) وأربعة صفراء الحبوب (SC166، SC167، SC168، SC176)، وهجين ثلاثي أبيض الحبوب (TWC321). وتضمنت التجربة الحقلية علي كثافتين نباتيتين ٢٠٠٠٠ و ٣٥٠٠٠ نبات للفدان بما يعادل ٤٧٦١٩ و ٨٣٣٣٣ نبات للهكتار، وتم قياس الصفات النباتية والمحصولية خلال اعمار ٣٥ و ٧٥ و ١٠٥ يوم بعد الإنبات. تم استخدام تصميم القطع المنشقة spilt -plot في صورة قطاعات كاملة العشوائية بثلاث مكررات، وبلغت مساحة القطعة الفرعية sub-plot ١٨ م٢ تضمنت ست خطوط عرض كل منها ٠,٧٥ م وطول ٤ م، وزعت هجن الذرة الشامية في القطع الرئيسية بينما احتوت القطع الفرعية على الكثافتين النباتيتين.

أشارت النتائج أنه بزيادة الكثافة النباتة من ٤٧,٦١٩ الي ٨٣,٣٣٣ نبات للهكتار انخفض كل من قطر الساق من ٢٤,٥٣ الي ٢٠,٩١ مم ، محتوي الأوراق العلوية من الكلورفيل من ٤٦,٤٥ الي ٤٢,٠١ (وحدة SPAD) ، محتوي الأوراق السفلية من الكلورفيل من ٣٦,٧٤ الي ٣١,٣١ (وحدة SPAD)، وعدد الكيزان علي النبات من ١,٣٨ الي ١,١٠ كوز ، وزن النبات الجاف من ٢٩٣ الي ١٩٥ جم. وحققت الكثافات النباتية المدروسة بعد ٣٥ يوماً بعد الإنبات تماثلاً معنوياً في وزن النبات الجاف ، بينما أعطت الكثافة النباتية المنخفضة (٤٧,٦١٩ نبات للهكتار) أثقل وزن جاف للنبات بعد ٧٠ أو ١٠٥ يوم بعد الإنبات (٢٧٩ و ٥٨٤ جم للنبات علي التوالي). وقد أوضحت النتائج أن معدل النمو النسبي لهجن الذرة الشامية خلال مرحلة النمو الأولى (٣٥-٧٠ يوم بعد الإنبات) كان أعلى معنوياً من القيم المقاسة في مرحلة النمو المتأخرة (٧٠-١٠٥ يوم من الإنبات) حيث كان أعلي معدل نمو نسبي خلال مرحلة النمو المبكرة للهجن الفردية ١٠ و ١٢٨ و ١٣١ و ١٦٨ و ١٧٦ , بينما أظهر كل من الهجين الفردي ١٦٧ و الهجين الثلاثي ٣٢١ قيماً أقل معنوياً. وخلال مرحلة النمو المتأخرة (٧٠-١٠٥ يوم بعد الإنبات) أظهرت قيم معدل النمو النسبي لجميع الهجن تماثلا. وقد أوضح تأثير الكثافة النباتية علي محصول العلف الجاف الكلي كمتوسط لجميع هجن الذرة الشامية ومراحل النمو المدروسة أن أعلي محصول علف كلي سجل معنوياً تحت الكثافة النباتية ٨٣,٣٣٣ نبات للهكتار (١٥,٧٠ طن للهكتار) ، بينما سجلت الكثافة النباتية ٤٧,٦١٩ نبات للهكتار المحصول الأقل معنوياً (١٣,٩٢ طن للهكتار). فيما يتعلق بمحصول البروتين تم تقسيم هجن الذرة إلى مجموعتين متفارقتين معنوياً. المجموعة المتفوقة ذات قيم ٢,١٩ و ١,٩٦ و ١,٩٦ و ١,٦١ و ١,٨٤ (طن للهكتار) تضمنت الهجن الفردية ١٠ و ١٣١ و ١٦٨ و ١٢٨و ١٧٦، علي التوالي، والمجموعة المنخفضة ذات قيم ١,٥٩ و ١,٤٥ و ١,٢٠ (طن للهكتار) وتضمنت الهجين الفردي ١٦٧و الهجين الثلاثي ٣٢١ والهجين الفردي ١٦٦ علي التوال

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