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DYNAMICS OF YIELD OF FOURTEEN WHITE AND YELLOW MAIZE (*Zea mays* L.) HYBRIDS GROWN IN EGYPT

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ABSTRACT

Two field experiments were carried out at Gemmeiza Agricultural Research Station in 1999 and 2000 seasons to study dynamics of yield of fourteen white and yellow maize hybrids. These hybrids were nine white single and three way crosses *i.e.* SC10, SC21, SC22, SC23 and SC24, TWC321, TWC 322,TWC 323 and TWC 324; and five yellow single and three-way crosses *i.e.* SC 51, SC52 and SC155; TWC 351 and TWC 352.

Results obtained can be summarized as follows: -

1- Variety differences were obtained in growth parameters, *i.e.* grain yield and its components, and photosynthates partitioning, where maize hybrids differed in glucose required for synthesis, carbon equivalent, yield energy per plant and/or per fed. for grain and straw yield, biological yield per fed (above ground biomass/fed), coefficient of crop index and harvest index.
2- Maize grain yield could be increased by growing white single crosses 10 and 22, yellow single cross 155; white three way crosses 321 and 322 and the yellow three way cross 352, where, these hybrids characterized by their highest value from vegetative growth; grain yield and its components and photosynthetic partitioning towards the economic yield in comparison with other eight white and yellow hybrids under study.

INTRODUCTION

The expansion in cultivating high yielding, single and three way cross maize hybrids, particularly those bred and developed in Egypt resulted in increasing grain yield especially due to following the technical recommendations of maize production .The agricultural policy of Egypt gives a great attention to increase maize production using both vertical and horizontal ways. The yield potential of maize plant can be defined as the total biomass produced or the economic part of the crop. The total biomass is a result of the integration of metabolic activity of the plant at any period of its growth, which can affect grain yield. Metabolic processes in maize plant are greatly governed by both internal i.e. genetic make up of the plant and external conditions, which involve two main factors namely climatic and edaphic environmental factors. The yield potential of maize could be regulated through alternation of genetic structure through breeding programs and/or by modifications of environment through improving cultural treatments.

However, Egyptian maize hybrids may differ in their assimilating capacity and distribution of photosynthates between the various plant organs which could be referred to as " Source and sink relation ". Yield dynamics means having a certain yield by changing the yield components, *i.e.* number of rows per ear, number of kernels per row and average grain yield weight per ear. In this respect, Prior and Russel (1976) indicated that maximum production could be obtained by providing an adequate sink for photosynthate transfer. They added that in many cases P and K applications proved to increase grain yield and affect growth characters. However, in some instances they had no effect on yield and growth characters. Amer *et al.* (1995), Mallarino *et al.*(1999) and Khalifa etal(2002) reported significant increase in grain yield as a result of P application and found that some of the growth characters were affected. However, Ainer (1976) showed that P application did not affect yield or yield components.

The objective of this study was to analyse the growth and development of high yielding maize hybrids, which are recently in a widespread use in Egypt, to determine the plant factors affecting yield. In this study, growth and development of the plant were studied at fifteen days intervals starting from 75 days up to 105 days after planting to determine how the yield components developed. It is hoped that through understanding of the dynamics of yield, area of possible improvement may be shown which would help maize breeder to develop a higher yielding maize hybrid

MATERIALS AND METHODS

A number of fourteen maize single and three way crosses were developed by the National Maize Research Program, Field Crops Research Institute, ARC, Egypt, during the period from 1983 to 1995. Those hybrids were used for the purpose of this study were nine white single and three way crosses, *i.e.* SC10, SC21, SC22, SC23, SC24, TWC321, TWC 322, TWC323 and TWC324. The other five hybrids were yellow single and three way crosses, *i.e.* SC 51, SC52, SC155, TWC 351 and T352. These hybrids were evaluated in two field experiments; at Gemmaiza Agricultural Research Station in Gharbia Governorate in 1999 and 2000-normal seasons.

A randomized complete block design with six replications was used in each experiment, where three replications were adopted for vegetative growth studies and the other three replications for yield and its components. The experimental plot consisted of seven rows, each of 5m long and 80cm apart. Planting was performed in hills evenly distributed at 25cm along the row at the rate of 2 seeds per hill. Plants were thinned later to one plant per hill, providing for a population density of 22000 plants /fed Fertilizers were applied at the rate of 120:30:24 kg N:P:K per fed Other agricultural practices were carried out as recommended. Planting dates were on June in the two seasons. Samples of five guarded plants were taken at random for growth measurements and chemical analysis at 75, 90 and 105 days from planting. The following growth attributes were recorded, *i.e.* plant height (cm), number of active green leaves and number of ears per plant, stalk sheath, blades and ears dry weight per plants and stalk diameter. Furthermore, flag leaf, 4th leaf and leaves area per plant were calculated according to Bremner and Taha (1966), where specific leaf weight (SLW) calculated according to Pearce et *al* (1969), leaf area index as Watson (1952) and specific leaf area (SLA) calculated according to Abdel Gawad *et al* (1987). In addition, flag leaf and 4th leaf angle were recorded according to Pendelton *et al*(1968) between the leaf and stalk. On the other hand, number of days to 50% silking and pollen shedding were calculated.

At harvest, ten guarded plants were taken out at random from the middle two rows of each plot to determine yield attributes, i.e. kernels, straw, above ground biomass (biological) yield per plant (gm), number of ears per plant, ears dry weight per plant, number of rows per ear, number of kernels per row, ear length, ear height, seed index and migration coefficient (ears dry wt. per total plant dry weight). Relative photosynthetic potential (RPP) for biological and kernels yield and vegetative organs were calculated according to the method described by Vidovic and Pokorny (1973). Where, $RPP_{kr}= Y_{kr}$ per plant/LAI, $RPP_{bio}= Y_{bio}$ per plant/LAI and $RPP_{veg}= RPP_{bio}-RPP_{kr}$. In addition, kernels, straw and biological yield were determined from the other three middle rows of each plot, where crop index, harvest index and migration coefficient were estimated according to Abdel Gawad *et al.* (1987). To study photosynthates partitioning of the fourteen white and yellow maize hybrids, Crop growth rate (CGR_g / cm^2 /day) was determined by multiplying NAR x LAI according to Abdel Gawad *et al.* (1987) In addition, the percentage of carbohydrate and protein were estimated in vegetative organs, kernels, straw and oil of kernels. Although plants composition changes with the age, these values may be fairly enough to provide an estimate of the partitioning coefficients. To calculate the photosynthates required to produce the different constituents, carbon equivalent was determined as shown by Hanson *et al* (1960). The production value (PV for the previous plant components was determined according to Penning De Vries *et al* (1974). The conversion factor to estimate carbon equivalent, production value, glucose required for synthesis, stored gram atoms, work carbon required in synthesis of carbohydrate, protein, and oil in the different plant components, as well as energy coefficient of crop index and energy coefficient of harvest index were calculated according to Abdel Gawad *et al.* (1987). The total carbohydrate (%) in the different organs was determined according to the methods shown by Dubois *et al.* (1956). Total nitrogen (%) was determined according to Cole and Parks (1946) and was multiplied by 6.25 to calculate protein (%). Crude oil (%) was determined by using the method described by A.O.C.S. (1964). In addition, energy per plant and per fed at harvest was calculated by using caloric conversion factors according to Hanson *et al.* (1960). Analysis of variance was performed for the combined data over the two seasons according to Steel and Torrie (1980). L.S.D at 0.05 level of significance was calculated to test the difference between treatment means.

RESULTS AND DISCUSSION

A - Growth Analysis:

Data presented in Table (1) show that there were significant differences among the fourteen maize hybrids under study, i.e. the white single crosses 10, 21, 22, 23 and 24, the yellow single crosses 51, 52, and 155, the white three way crosses 321, 322, 323, and 324, and the two yellow three way hybrids 351 and 352 in growth parameters, *i.e.* plant height, stalk diameter, number of active leaves per plant (except at 75 and 105 days age), stalk sheath dry weight per plant, blades dry weight per plant, ears dry weight per plant, flag leaf angle, 4^{th} leaf angle (except at 105 days age), flag leaf area, 4^{th} leaf area, blades area per plant, LAI and SLW. On the other hand, the differences among hybrids did not reach the level of significance for number of ears per plant at the three sampling dates (Tables-1&2). In respect of number of days to 50% silking and grain polling, the differences between hybrids were significant (Table 2).

It is worthy to mention that the plant height,(cm), stalk diameter, stem sheaths dry weight per plant, ears dry weight per plant, flag leaf angle and 4th leaf angle tended to increase with advance of plant age up to 105 day after planting (Table-1). Meanwhile, number of active leaves per plant, blades dry weight per plant, flag leaf area, 4th leaf area, blades area per plant, and LAI increased up to 90 days after planting and there after decreased. However, the fourteen maize hybrids under this study did not represent a constant line in each of number of ears/plant and specific leaf weight (SLW) and their variation with the advance of plant age (Table 1).

Data illustrated in (Table 1) show that S.C.10 gave the highest plant height (cm), number of active leaves/plant, blades dry weight/ plant (gm), ears dry weight/plant, flag leaf area, 4th leaf area (except at 75 days age), blades area/plant, LAI and specific leaf weight and the more planophile flag leaf and *4th* leaf after 75, 90 and 105 days from planting and number of ears/plant after 105 days from planting date. In addition, TWC 352 hybrid had the largest stalk diameter and equaled with TWC 352 at 90 and 105 days age, meanwhile, TWC 321 gave the maximum stem sheath dry weight/plant (gm) at the three plant samples.

Regarding the nine white maize hybrids; SC 10 surpassed the other four white single cross hybrids, i.e. 21, 22, 23 and 24 in plant height, number of active leaves/plant, number of ears/plant, blades dry weight/plant, ears dry weight/plant (Table-1). It showed, also, more planophile flag leaf and *4th* leaf angles, flag leaf area, 4th leaf area, blades area /plant, LAI and SLW. However, TWC 321 outweighed other three way white hybrids 322,323 and 324 in stem sheath dry weight/plant, the more planophile flag leaf angle and 4th leaf angle, flag leaf area, 4th leaf area, blades area per plant and LAI at different stages of growth, plant height and ears dry weight/plant at 75 days age, and number of active leaves/plant at 90 days age. However, T.W.C322 showed the greatest blades dry weight at the different vegetative growth stages, and gave the highest plant height(cm), stalk diameter (cm) at 90 days, ears dry weight at 90 and 105 days, also, and SLW at 105 days after planting. On the other hand, T.W.C-321 and 322 produced equal values of stalk diameter at 105 days and number of ears per plant after 90 and 105 days from planting and surpassed other hybrids T.W.C323 and 324 in these two growth characters. Furthermore, T.W.C 323 had the largest plant height at 105 days and SLW at 90 days after planting, meanwhile, T.W.C 324 hybrid had the maximum values of stalk diameter and SLW at 75 days, and number of active leaves/plant after 75 and 105 days from planting compared with other three way white hybrids in this study (Table 1).

Regarding the five yellow maize hybrids, data recorded in Table (1) showed that the yellow single cross 155 had the maximum plant height(cm), stalk diameter (cm), (except at 75 days), number of active leaves per plant, number of ears per plant, stalk sheath dry weight per plant, blades dry weight per plant, ears dry weight per plant, more planophite flag leaf angle,

Table 1: Varietal differences in growth characters of the evaluated fourteen maize hybrids.(Average of 1999 and 2000 seasons)

Hybrids	S.C	S.C	S.C	S.C	S.C	S.C	S.C	S.C	TWC	TWC	TWC	TWC	TWC	TWC	L.S.D
Days after planting	10	21	22	23	24	51	52	155	321	322	323	324	351	352	5%
Plant height (cm.)															
75	247.3	238.2	226.4	230.1	232.2	208.3	214.9	224.4	239.3	234.7	236.0	237.6	211.3	227.8	3.3
90	308.0	281.0	290.1	296.0	300.0	262.9	281.3	296.0	290.0	298.0	293.3	287.2	287.4	292.5	2.7
105	323.9	305.2	306.3	307.5	308.0	300.8	294.0	302 .1	300.7	303.5	305.5	298.3	293.3	298.1	11.7
Stem diameter (cm.)															
75	1.74	1.88	1.92	1.96	1.92	1.84	1.92	1.89	2.00	2.01	2.01	2.03	2.11	2.14	0.02
90	1.97	2.00	2.04	2.05	2.06	1.95	2.03	2.05	2.13	2.15	2.08	2.10	2.20	2.20	0.06
105	2.14	2.26	2.37	2.32	2.38	2.12	2.27	2.35	2.47	2.47	2.42	2.45	2.50	2.50	0.02
Number of active leaves/plant															
75	16.8	15.5	15.9	16.2	16.0	14.7	15.0	15.9	15.3	15.3	15.6	15.7	16.4	16.7	n.s
90	19.2	17.0	17.3	17.0	18.0	17.2	16.6	17.4	16.7	16.0	16.6	16.6	18.0	18.3	0.3
105	17.6	15.9	16.8	16.7	16.7	16.8	16.0	17.0	16.0	15.6	15.9	16.4	16.7	16.7	n.s
Number of ears/plant															
75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	n.s
90	1.2	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.1	1.1	1.0	1.1	n.s
105	1.3	1.1	1.1	1.0	1.0	1.0	1.0	1.1	1.2	1.2	1.1	1.1	1.1	1.2	n.s
Stem & sheath dry weight (g./plant)															
75	102.5	139.3	126.4	128.5	134.3	116.6	118.2	123.0	147.4	110.5	118.3	112.8	121.8	125.3	6.9
0	155.6	168.0	171.0	184.9	187.4	159.0	162.5	167.3	198.7	159.7	157.4	160.2	177.6	179.4	15.2
5	168.9	190.9	194.7	195.1	197.8	147.5	151.4	154.7	201.9	170.1	169.0	166.1	186.4	189.4	6.2
Blades dry weight (g./plant)															
75	25.1	19.4	20.4	21.3	22.6	16.9	17.2	18.7	20.1	20.4	19.5	19.8	22.1	23.2	1.9
90	36.4	28.5	29.1	30.8	31.3	22.7	24.9	25.1	26.38	26.6	25.8	25.9	27.5	28.3	1.7
105	29.1	24.2	2.9	26.4	25.6	20.0	21.3	21.6	23.2	23.7	22.3	22.7	23.7	24.8	2.8
Ears dry weight (g/plant)															
75	59.2	53.0	54.5	48.2	48.1	44.6	45.6	47.2	49.2	49.1	48.0	48.8	48.8	50.9	2.6
90	98.4	82.1	85.0	88.3	90.5	70.5	85.2	91.3	80.2	82.4	81.4	81.5	89.7	92.5	3.4
105	134.3	113.0	117.2	120.0	122.7	117.1	118.5	119.1	112.9	113.7	111.3	111.6	115.8	117.3	3.5

Cont. 1

Flag leaf angle														
75	37.9	39.3	40.7	41.7	42.5	43.0	43.8	42.8	39.8	40.1	40.3	40.8	40.1	39.9	2.6
90	38.5	42.6	43.3	45.6	48.3	45.1	49.0	43.4	42.1	44.2	44.9	47.2	43.5	43.1	3.1
105	57.2	64.8	65.3	66.5	67.4	65.5	64.2	60.0	61.5	62.1	64.5	65.0	61.8	61.3	4.2
4th leaf angle															
75	47.2	52.4	55.1	56.2	58.3	54.1	58.5	57.1	51.5	51.8	54.7	54.1	51.4	50.1	3.6
90	56.1	58.2	60.9	62.1	62.4	61.7	64.3	60.4	60.3	61.8	62.0	62.1	61.1	60.0	1.4
105	64.5	67.6	68.1	69.2	69.5	65.1	65.8	67.1	65.2	65.3	67.1	67.3	68.1	66.7	n.s
Flag leaf area cm^2															
75	134.4	112.3	114.5	118.7	120.0	120.0	122.6	126.5	129.7	129.3	122.5	122.9	126.0	130.1	3.2
90	164.2	138.4	141.0	148.9	153.8	138.5	140.4	142.9	1493	146.1	136.7	138.4	142.5	143.6	7.9
105	159.6	135.0	137.3	138.5	144.5	126.2	129.5	131.5	136.0	133.9	130.6	130.9	134.5	136.0	8.0
4th leaf area															
75	458.5	423.2	422.1	427.3	415.4	372.2	481.3	413.5	426.8	422.0	376.1	384.3	408.2	413.0	11.5
90	562.0	529.0	480.9	493.0	486.9	498.2	496.1	503.4	522.6	515.0	463.0	485.5	514.0	518.5	15.0
105	523.0	474.6	472.0	469.2	462.0	448.0	449.0	458.3	485.1	438.3	446.5	448.8	480.5	483.8	11.2
Blades area (cm^2/plant)															
75	4434.9	4227.2	4131.7	4152.8	4131.7	4001.1	4003.5	4116.7	4118.3	4113.8	3983.9	3919.1	4163.8	4382.8	18.4
90	6096.4	5460.1	5322.4	5300.8	5463.1	5158.2	5234.5	5444.6	5313.0	5216.3	5008.0	5092.0	5119.7	5295.5	15.1
105	5622.9	5315.7	5158.0	5270.1	5229.4	4261.0	4346.0	4367.0	4691.0	4658.0	4651.0	4678.5	4831.1	5013.0	28.0
Leaf area index (LAI)															
75	2.96	2.82	2.75	2.77	2.75	2.67	2.66	2.74	2.75	2.74	2.66	2.61	2.74	2.76	0.08
90	4.06	3.64	3.55	3.53	3.64	3.44	3.49	3.63	3.54	3.48	3.33	3.39	3.41	3.53	0.11
105	3.75	2.88	2.77	2.85	2.82	2.84	2.90	2.91	3.13	3.04	3.10	3.11	3.22	3.34	0.04
Specific leaf weight (mg/cm^2)															
75	5.66	4.59	4.94	5.13	5.47	4.30	4.30	4.54	4.89	4.96	4.89	5.05	5.31	5.29	0.20
90	5.97	5.22	5.47	5.81	5.73	4.40	4.76	4.61	4.97	5.10	5.15	5.08	5.37	5.34	0.17
105	5.18	4.55	5.02	5.01	4.90	4.69	4.90	4.97	4.95	5.09	4.79	4.85	4.91	4.95	0.19

4^{th} leaf angle per flag leaf area, *4th* leaf area (except at 75 days age), blades area per plant, LAI and SLW (except at 90 days age) at the three sampling dates; whereas; the yellow S.C 52 had the maximum stalk diameter , 4^{th} leaf area at 75 days and S.L.W at 90 days age compared with other two yellow single cross hybrids 51 and 155. On the other hand, the comparison between the two yellow three way hybrids 351 and 352; data reported in Table (1) manifested that TWC 352 exceeded TWC 351 in growth parameters under study, except SLW at 75 and 90 days and stalk diameter at 90 and 105 days after planting.

In respect of the number of days to 50% silking and pollen shedding data shown in Table (2) illustrated that differences among the studied hybrids were significant. Furthermore, T.W.C 352 hybrids were the earlier in 50% silking and pollen in comparison with the other thirteen maize hybrids under study. However, days to 50% silking in the other yellow maize hybrids ranged from 58 (SC.52 and T.W.C 351) to 59 day for SC.155.

It is worthy to mention that variety differences in growth parameters of the evaluated hybrids are in agreement with the results previously obtained by Gardener and Me Cloud (1990), Beuvenuti and Beeline (1990), Ahmed and Sadek (1992), Ahmed *et al* (1994), Salama *et al* (1994), , Saneoka (1996), Szunday *et al* (1997), Zaki *et al* (1999) and Ahmed and Hassanein (2000). Furthermore, variety differences in growth parameters in this study may be due to differences in genetic structure and to variety differences in photosynthates partitioning El-Sherbieny *et al,* (1994) and (Sadek *et al* 1994 a and b and Clark *et al*,(1997).

B – Yield and its components:

There were significant differences among the fourteen white and yellow maize hybrids in yield and yield components, i.e. plant height(cm), ear height(cm). ear length(cm), ear diameter(cm), number of rows/ear, number of kernels/row, seed index, migration coefficient, $RPP_{kr.}$, $RPP_{bio.}$, $RPP_{veg.}$, grain yield/plant(gm), straw yield/plant, kernels, straw and aboveground biomass yields/fed, crop index, and harvest index. On the other hand, differences between hybrids in number of ears/plant failed to reach the significant level at 5% (Table 2).

Data reported in Table (2) showed that S.C. 10 gave the greatest values of plant height (cm), ear height(cm), ear length(cm), number of ears/plant, number of kernels/row, grain yield / plant(gm) and/ or fed, above ground biomass/fed., crop index and harvest index. Meanwhile, T.W.C 352 had the highest ear diameter; number of rows/ear and straw yield/plant, as well as SC. 155 gave the same value for number of rows/ear. T.W.C 323 and 324 had the highest seed index, and S.C 51 gave the maximum migration coefficient. Moreover, S.C.22 gave the maximum RPPkr and RPPbio, as well as T.W.C 324 produced the highest RPPveg. While, S.C. 155 gave the maximum straw yield / fed.

In respect of the five white single hybrids, i.e S.C. 10, S.C 21, S.C. 22, S.C. 23 and S.C 24, data illustrated in Table (2) confirmed that S.C. 10 had the maximum values of plant height(cm), ear height(cm), ear length(cm), ear diameter(cm), number of kernels/ row, migration coefficient, grain yield/plant(gm) and/or fed, above ground biomass/fed, crop index and harvest index. On the other hand, S.C. 21 had the greatest straw yield / plant, S.C. 22 gave the highest RPPkr, RPPbio and RPPveg. , S.C. 23 produced the greatest straw yield / fed and S.C. 24 gave the maximum number of rows / ear and seed index.

Regarding the three yellow single hybrids, i.e. S.C. 51, S.C. 52 and S.C. 155, it is clear from Table (2) that S.C. 155 had the maximum values of plant height(cm), ear length(cm), ear diameter(cm), number of ears/plant, number of rows/ear, seed index, $RPP_{kr,}$ Kernel yield/plant and/or fed, straw yield/fed and above ground biomass/fed, while, S.C. 51 gave the greatest ear height, number of kernels/row, migration coefficient, crop index and harvest index, S.C. 52 gave the highest $RPP_{bio,}$ $RPP_{veg,}$ and straw yield/plant.

It is worthy to mention that T.W.C 321 exceeded the other white three way hybrids T.W.C 322, T.W.C 323 and T.W.C 324 in ear height, number of rows/ear migration coefficient, $RPP_{kr,}$ grain yield/plant and/or fed, and harvest index, meanwhile, T.W.C 322 gave the maximum plant height, number of kernels/row, and above ground biomass/fed, where as T.W.C 323 had the greatest $RPP_{bio,}$ T.W.C 324 gave the maximum. RPP_{kr}, and straw yield/plant and/or fed. Furthermore T.W.C323 and T.W.C 324 are equal and gave the maximum seed index also, T.W.C 321 and T.W.C 322 for ear diameter, number of ears/plant, and crop index in comparison with other white three way hybrids under study.

On the other hand, in comparison between the two yellow three way hybrids T.W.C 351 and T.W.C 352, data reported in Table (2) showed that T.W.C 352 exceeded T.W.C 351 in plant height(cm), ear height(cm), ear length(cm), ear diameter(cm), ears/plant, number of rows/ear, number of kernels/row, seed index, RPP_{kr}, RPP_{bio}, kernel yield/plant, straw yield/plant, and kernels, straw and above ground biomass yield /fed. While, T.W.C 351 had the maximum RPP_{veg} and harvest index. On the other hand, T.W.C351 and T.W.C 352 were equal and gave the same values of migration coefficient, and crop index.

These results are in agreement with those obtained by Ahmed and Sadek (1992), Ahmed *et al.* (1994 a) Sadek *et al.* (1994), Salama *et al.* (1994 b), Osaki (1995 a) and Begna *et al.* (1997). In addition, hybrid differences in yield and its components may be due to differences in genetic structure between maize hybrids and to the hybrid differences in photosynthates partitioning. Similar findings were previously obtained by EL. Sherbeny *et al* (1994) and Sadek *et al* (1994 a and b), also, to the widely differences between maize hybrids for mineral concentrations (Clark *et al*, 1997).

C - Photosynthates Partitioning:

The partitioning coefficient would be determined by the capacity of the photosynthetic sink created by the ears. When plants reached the final weeks of the filling period, the partitioning coefficient may increase. Evidence for these is shown by the every rapid decline in the canopy in the final weeks and the possible scavenging of nutrients from the vegetative plant parts.

There were significant differences among maize hybrids in crop growth rate and ears dry weight per plant at different stages of growth, where, the white single hybrid S.C.10 produced the highest values of crop growth rate at 75 - 90 day period and 90 - 105 days period. The maximum vegetative growth rate at 75 - 90 days after planting was 10.53, 7.10, 6.16, 5.70, 6.40, 6.73, 5.27, 8.14, 7.12, 7.36, 5.29, 5.36, 7.18, and 7.39 "$mg/cm^2/day$" for the fourteen maize hybrids S.C.10, S.C.21, S.C 22, S.C.23, S.C.24, S.C.51, S.C.52, S.C.155, T.W.C 321, T.W.C 322, T.W.C 323, T.W.C 324, T.W.C 351 and T.W.C352, respectively (Table3). These values reflect the total amount of photosynthetic available for plant growth in terms of the accumulation of dry matter (Table 1). On the other hand, the dry weight of ears/plant increased linearly from 75 days age (Table-1). However, the average crop growth rate during 90 - 105 days period (Table3) was 5.90, 4.16, 3.62, 3.35, 4.94, 4.96, 3.28, 4.57, 4.27, 3.26, 2.41, 2.42, 2.25, and 3.56, for the same above-mentioned hybrids in the same order (Table-4). These values reflect the total amount of photosynthetic partitioned into the yield components. The partitioning coefficient can not be approximated from a simple reaction of the slope of crop growth rate since more plotosynthate is required to produce a given amount of kernels that the same amount of vegetative material, the additional photosynthate is required to produce the additional protein and oil in the kernels (Hanson *et al*, 1960, lenning De Vries *et al*, 1974 and, Mc Grow, 1977).

To estimate the amount of photosynthate needed to produce a quantity of ears vs. the same quantity of vegetative material, the relative quantities of carbohydrate, protein and oil should be detected. Significant differences were observed among the fourteen maize hybrids in carbohydrate in vegetative organs, kernels and straw. Significant differences were also observed in protein and oil percentages in kernels. However, hybrid differences in protein percentage in vegetative organs and straw were insignificant. On the other hand, T.W.C352 surpassed the other thirteen hybrids in carbohydrate percentage in vegetative organs. Meanwhile, S.C.10 gave the highest percentage of protein in vegetative organs and exceeded the other thirteen maize hybrids in these chemical components. Regarding chemical components of kernel, S.C.21 had the greatest mean value of carbohydrate percentage, whereas S.C.155 produced the highest values of protein and oil percentages in kernels, compared to the other hybrids under study. On the other hand, S.C. 21 gave the greatest carbohydrate in straw; however, S.C.51 exceeded other hybrids under study in protein percentage in straw, (Table 3).

Data presented in table (3) showed that the glucose required for synthesis of the compound by the various maize hybrids components. Differences among maize hybrids in glucose required for synthesis of carbohydrate in vegetative organs, kernels/and straw, as well as synthesis of protein in vegetative organs and of oil in kernel were significant, whereas, hybrid differences in protein percentage in kernel and straw were, insignificant T.W.C 352 required more glucose for synthesis of carbohydrate

Table 2: Varietal differences in yield and its components and number of days to 50 % of silking and pollen shedding of the studied fourteen maize hybrids (Average of 1999 and 2000 season)

Yield & its Components / Hybrids	Plant height cm	Ear height cm	Ear length cm	Ear diameter cm	No. of ears/plant	No. of rows/ear	No. of kernels/row	Seed index	Migration coefficient	RPP kr/LAI	RPP bob/LAI	RPP veg g/LAI	No. of days to 50% silking	No. of days 50% pollen	Grain yield/plant gm	Straw yield/ plant gm	Grain yield/ ton/fed	Straw yield ton/fed	Above ground biomass ton/fed	Crop index	Harvest index
S.C. 10	318.7	180.1	23.6	5.0	1.2	14.2	54.3	40.8	0.58	71.9	148.1	76.2	61.0	60.5	258.3	273.3	4.32	2.69	7.01	0.62	1.61
S.C.21	300.4	160.2	20.6	4.6	1.0	14.0	48.0	41.6	0.57	74.3	166.6	92.3	60.0	59.3	231.0	287.0	3.76	2.55	6.31	0.60	1.47
S.C22	301.5	165.5	20.4	4.6	1.0	14.0	49.1	41.5	0.56	79.2	171.9	92.7	60.0	59.5	239.0	280.1	3.82	2.60	6.42	0.60	1.47
S.C.23	300.8	169.4	20.3	4.8	1.0	14.2	46.3	42.4	0.57	77.0	168.5	91.5	60.6	60.0	234.9	279.0	3.60	2.72	6.32	0.57	1.32
S.C.24	305.0	167.0	20.2	4.7	1.0	14.8	44.0	42.6	0.53	75.3	164.6	89.3	60.2	60.0	231.1	274.2	3.67	2.70	6.37	0.58	1.36
S.C.51	302.8	156.0	20.0	4.7	1.0	14.0	43.0	33.2	0.60	71.1	157.8	86.7	58.3	58.0	211.8	258.4	3.35	2.91	6.26	0.54	1.15
S.C. 52	304.9	149.0	19.8	4.7	1.0	14.2	42.8	34.6	0.58	72.3	160.2	87.9	58.0	57.3	218.2	265.5	3.47	2.08	6.55	0.53	1.13
S.C. 155	307.6	153.0	20.6	4.8	1.1	16.0	40.3	36.1	0.58	72.8	157.0	84.2	59	58.5	224.8	260.4	3.69	3.25	6.94	0.53	1.14
T.W.C 321	311.8	170.0	21.4	5.2	1.1	14.8	47.9	44.2	0.58	75.0	161.1	86.1	60.2	59.3	232.4	267.0	4.02	2.63	6.65	0.60	1.53
T.W. C322	312.7	169.3	21.6	5.2	1.1	14.7	48.3	44.4	0.57	73.5	166.8	93.3	60.3	59.6	228.5	290.3	3.98	2.70	6.68	0.60	1.47
T.W. C323	310.2	169.5	21.2	5.0	1.0	14.2	46.2	44.6	0.54	73.4	171.4	98.0	60.5	59.8	222.3	297.1	3.82	2.64	6.46	0.59	1.45
T.W. C324	310.6	162.8	21.1	4.9	1.0	14.2	46.8	44.6	0.55	72.2	171.3	99.1	60.5	59.6	219.6	301.2	3.71	2.82	6.53	0.57	1.32
T.W. C351	299.5	161.8	18.6	5.2	1.0	15.8	43.8	37.9	0.52	66.6	162.6	96.0	58.0	57.5	207.9	299.5	3.28	3.05	6.33	0.52	1.08
T.W. C352	301.2	166.3	18.8	5.4	1.1	16.0	44.1	38.8	0.52	68.7	163.0	94.3	57.9	57.2	220.5	302.7	3.43	3.20	6.63	0.52	1.07
LSD 5 %	5.3	5.4	1.2	0.2	ns	0.7	1.3	1.6	0.03	3.5	9.4	2.7	0.6	0.9	4.1	7.0	0.13	0.06	0.11	0.03	0.09

Table 3: Varietal differences in glucose required for synthesis and carbon equivalent for the vegetative parts, kernels, and straw components and crop growth rate of the evaluated fourteen maize hybrids. (Averages of 1999 and 2000 seasons)

Hybrids / Characters	S.C 10	S.C 21	S.C 22	S.C 23	S.C 24	S.C 51	S.C 52	S.C 155	T.W.C 321	T.W.C 322	T.W.C 323	T.W.C 324	T.W.C 351	T.W.C 352	L.S.D 5%
Carbohydrate, Protein and Oil Percentages															
Vegetative organs															
Carbohydrate	68.25	69.00	70.90	68.75	70.42	70.02	70.60	71.64	71.35	71.55	71.74	71.65	71.70	72.19	0.04
Protein	10.87	9.95	10.06	10.09	10.06	10.12	10.12	10.06	9.70	9.35	9.48	9.38	9.95	10.09	n.s
Kernels															
Carbohydrate	69.90	71.35	70.6	70.90	69.00	68.24	68.54	68.28	65.60	65.80	65.26	65.23	67.20	67.24	0.12
Protein	12.15	11.91	12.27	12.20	12.27	12.67	12.70	12.83	11.79	11.65	11.58	11.37	11.45	11.60	0.15
Oil	4.85	4.95	4.91	4.86	5.65	5.44	5.62	5.68	5.65	5.61	5.45	5.48	5.27	5.60	0.03
Straw															
Carbohydrate	70.00	71.89	70.70	71.70	69.00	69.00	68.54	68.24	46.55	64.24	64.13	65.20	66.00	66.17	2.97
Protein	11.31	11.35	11.45	11.56	11.57	11.68	11.39	11.57	11.40	11.38	10.94	11.44	11.40	11.52	n.s
Glucose required for sunthesis															
Vegetative organs															
Carbohydrate	0.80	0.81	0.831	0.806	0.826	0.821	0.828	0.840	0.835	0.839	0.841	0.842	0.842	0.846	0.02
Protein	0.75	0.161	0.162	0.163	0.162	0.163	0.163	0.162	0.157	0.151	0.153	0.152	0.161	0.163	0.01
Kernels															
Carbohydrate	0.82	0.835	0.828	0.831	0.810	0.800	0.804	0.800	0.770	0.770	0.765	0.765	0.788	0.788	0.12
Protein	0.196	0.192	0.198	0.197	0.198	0.204	0.204	0.208	0.190	0.188	0.187	0.184	0.185	0.187	n.s
Oil	0.138	0.141	0.140	0.139	0.163	0.160	0.162	0.164	0.163	0.162	0.160	0.156	0.150	0.160	0.01
Straw															
Carbohydrate	0.81	0.842	0.829	0.842	0.810	0.810	0.804	0.800	0.755	0.753	0.752	0.764	0.770	0.776	0.07
Protein	0.182	0.183	0.185	0.186	0.187	0.188	0.184	0.187	0.184	0.184	0.177	0.185	0.184	0.186	n.s
Carbon equivalent															
Vegetative organs															
Carbohydrate	27.30	27.60	28.36	27.50	28.17	28.01	28.24	28.66	28.54	28.60	28.70	28.66	28.68	28.88	0.05
Protein	8.54	7.83	7.91	7.94	7.91	7.96	7.96	7.91	7.62	7.35	7.45	7.37	7.83	7.94	0.01
Kernels															
Carbohydrate	27.96	28.54	28.24	28.36	27.60	27.30	27.42	27.31	27.60	27.60	26.10	26.09	26.88	26.90	0.08
Protein	9.55	9.51	9.65	9.60	9.65	9.96	9.99	10.09	9.28	9.16	9.10	9.08	9.10	9.12	n.s
Oil	5.54	5.65	5.60	5.55	6.96	6.22	6.42	6.46	6.46	6.40	6.22	6.26	6.02	6.40	0.02
Straw															
Carbohydrate	28.00	28.76	28.28	28.68	27.6	27.60	27.42	27.30	25.82	25.70	25.65	26.08	26.40	26.47	0.14
Protein	8.89	8.90	9.00	9.09	9.09	9.18	8.97	9.10	8.95	8.95	8.60	8.99	8.95	9.04	0.06
Crop Growth Rate mg cm^2/day															
a- 75-90 days after planting	10.53	7.10	6.16	5.70	6.40	6.73	5.27	8.14	7.12	7.36	5.29	5.36	7.18	7.39	2.62
b- 90--105 days after planting	5.90	4.16	3.62	3.35	4.94	4.96	3.28	4.75	4.27	3.26	2.41	2.42	2.25	3.56	0.55

by vegetative organs whereas, S.C.10 required more glucose for synthesis of protein by vegetative organs, also, with respect to glucose required for synthesis of chemical components by kernels, S.C.21 required more glucose for synthesis of carbohydrate. Meanwhile, S.C.155 required more glucose for synthesis of protein and oil. Regarding straw, S.C.21 required more glucose for synthesis of carbohydrate, however, S.C. 51 required more glucose for synthesis of protein in straw.

In respect of carbon equivalent, according to Hanson *et al.*(1960), carbon equivalent is defined as the gram atoms of sugar carbon required to produce an end product including both gram atoms of work carbon lost in the synthesis and gram atoms of carbon stored in the product. Data reported in Table (3) showed that significant differences were detected among maize hybrids in carbon equivalent for each carbohydrate of vegetative organs, kernels and straw, as well as, protein in vegetative organs and straw, and. oil in kernels. However, the hybrid differences in carbon equivalent for protein in kernels did not reach to the significant level at 5%. Moreover, TWC352 characterized with a high carbon equivalent for carbohydrate. Meanwhile, S.C.10 showed a high carbon equivalent for protein in vegetative organ. On the other hand, S.C.21 characterized with a high carbon equivalent for carbohydrate, whereas, S.C.155 characterized with a high carbon equivalent for protein and oil of kernels. In addition S.C.21 and S.C.51 characterized with a high carbon required for carbohydrate and protein in straw, respectively.

Data presented in Table (4) showed that there were significant differences among maize hybrids in yield energy per plant and per fed, where, maize hybrids significantly differed in energy yield for each of carbohydrate, protein and oil. S.C.10 surpassed the other thirteen maize hybrids under study in energy yield of carbohydrate and protein and total yield energy in kernels yield per plant and or per fed. Meanwhile, T.W.C321 gave the greatest energy yield for oil per kernels. Considering straw energy yield/plant at harvest S.C.21 outweighed other studied thirteen maize cultivars in energy yield for carbohydrate and total energy per straw. However, TWC352 characterized by the highest energy yield for protein in straw. Furthermore, data in Table (4) revealed that S.C.10 gave the greatest mean value of total energy for kernels yield per fed and energy yield for carbohydrate and protein. In addition, S.C. 51 exceeded other maize hybrids in total energy yield of straw per fed and its attributes (i.e. energy yield for carbohydrate and protein of straw). Regarding energy coefficient of crop index and harvest index, it is observed that S.C.10 was the highest hybrid in these two characters (Table 4). It is worthy to mention that the white single cross S.C.10 exceeded the other white single crosses; S.C.21, S.C.22, S.C.23 and S.C.24 in each of energy yield for carbohydrate and protein from kernels yield and total energy of kernels per plant and or / per fed.

In this respect, the present results are in a harmony with those obtained by Ahmed and Sadek (1992), El- Sherbieny *et al.* (1994), Gado *et al* (1994) and Sadek *et al.* (1994 a and b), who indicated that hybrids differed in partitioning and migration of the total available photosynthate to

Table 4: Varietal differences in energy/ grain, yield energy per plant and per fed. at harvest of the evaluated fourteen maize hybrids. (Average of 1999 and 2000 seasons)

Hybrid Characters	S.C 10	S.C 21	S.C 22	S.C 23	S.C 24	S.C 151	S.C 152	S.C 155	T.W.C 321	T.W.C 322	T.W.C 323	T.W.C 324	T.W.C 351	T.W.C 352	L.S.D 5%
Yield energy/P. at harvest K cals															
Kernels															
Carbohydrate	713.18	651.03	666.78	657.85	629.87	570.90	590.74	606.30	602.19	593.89	573.04	565.82	551.85	585.64	24.7
Protein	143.42	125.73	134.07	130.97	129.59	122.64	126.64	131.81	125.22	121.65	117.64	114.11	108.79	116.89	11.4
Oil	117.76	107.48	110.35	107.31	122.74	108.31	115.27	120.03	123.43	120.50	113.88	113.12	102.99	116.07	14.0
Total	974.36	884.24	911.02	896.13	882.20	801.85	832.65	858.14	850.84	83604	804.56	793.05	763.63	818.60	34.9
Straw															
Carbohydrate	755.67	814.98	782.22	790.17	747.33	704.27	718.80	701.90	680.78	736.63	752.59	775.71	780.80	791.17	15.3
Protein	141.26	148.87	146.57	147.39	144.98	137.93	138.20	137.69	139.10	150.98	148.54	157.47	156.03	159.36	18.8
Total	896.93	963.85	928.79	937.56	892.31	842.2	857.00	839.59	819.88	887.61	901.13	933.18	936.83	950.53	16.2
Yield energy/Feddan at harvest 1000 K cals															
Kernels															
Carbohydrate	1122.7	10596.9	10652.8	10081.9	10002.5	9029.86	9394.44	9952.15	10416.6	10344.4	9847.08	9559.13	8706.43	9110.01	306.4
Protein	2398.7	2046.52	2142.02	2007.14	2057.91	1939.71	2013.95	2163.56	2165.99	248.97	2021.57	1927.75	1716.31	1818.31	125.3
Oil	1969.4	1749.53	1763.08	1644.62	1949.14	1713.06	1833.13	1970.16	2135.02	2098.81	1956.99	1911.10	1624.85	1805.55	258.9
Total	16295.9	14392.95	14557.9	13733.74	14009.64	12682.63	13241.52	14085.87	14717.63	14562.2	13825.64	13397.98	12047.59	12733.87	133.7
Straw															
Carbohydrate	7437.9	7241.12	7260.89	7703.45	7358.85	7931.21	8338.58	8760.31	6705.78	6851.20	6687.48	7262.63	7951.35	8369.89	178.8
Protein	1390.4	1322.67	1360.49	1436.95	1427.62	1553.29	1603.21	1718.43	1370.18	1404.18	1319.89	1474.32	1588.99	1684.68	145.9
Total	8828.3	8563.79	8621.38	9140.4	8786.47	9484.50	9941.79	10478.74	8075.96	825538	8007.37	8736.59	9540.34	10048.57	147.5
Energy cofficient															
Energy coefficient of crop index	0.65	0.63	0.63	0.60	0.61	0.57	0.57	0.57	0.65	0.64	0.63	0.61	0.56	0.56	0.03
Energy coefficient of crop index	1.85	1.68	1.69	1.50	1.59	1.34	1.33	1.34	1.82	1.76	1.73	1.53	1.26	1.27	0.17

economic yield, in carbon equivalent for vegetative matter, kernels and straw, yield energy of kernels and straw per plant and per fed and energy coefficient of crop index and harvest index.

It can be concluded that the harvested maize yield can be increased by growing white single crosses, i.e. S.C.10 and S.C.22, the yellow single cross S.C.155, the white three way crosses 321 and 322, as well as, the yellow three way cross 352.

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ديناميكية المحصول في أربعة عشر هجيناً من الذرة الشامية البيضاء والصفراء المنزرعة في مصر

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تم إقامة تجربتين حقليتين بمحطة البحوث الزراعية بالجميزة موسمي ١٩٩٩، ٢٠٠٠ وذلك بغرض دراسة ديناميكية المحصول في أربعة عشر هجيناً من هجن الذرة الشامية منها تسعة هجن بيضاء الحبوب هي هـ.ف ١٠ ، هـ.ف ٢١ ، هـ.ف ٢٢ ، هـ.ف ٢٣ ، هـ.ف ٢٤, والهجن الثلاثية ٣٢١ ، ٣٢٢, ٣٢٣ ، ٣٢٤ ،.وخمسة هجن صفراء الحبوب هى هـ.ف ٥١ , هـ.ف ٥٢ , هـ.ف ١٥٥والهجينان الثلاثيان ٣٥١ ، ٣٥٢ ، وذلك بغرض دراسة متغيرات المحصول وتوظيف وهجرة المادة الجافة المتكونة في هجن الذرة الشامية تحت الدراسة لإمداد المربي بأفضل الصفات اللازمة في برنامج التربية والانتخاب للوصول للنبات المثالي مما يؤدي لتحديد أفضل التراكيب إنتاجية تحت الظروف المصرية.

وتتلخص النتائج المتحصل عليها فيما يأتى :-

١. كان هناك تباين بين الأصناف فى قياسات النمو ومحصول الحبوب ومكوناته بالإضافة الي مكونات التمثيل الضوئي حيث اختلفت الهجن في كميات الجلكوز والكربون المطلوبة وكذلك كمية الطاقة للنبات أو الفدان.كما وجدت تباينات في محصول القش و الحبوب ,والمحصول البيولوجي للفدان ومعامل دليل المحصول ودليل الحصاد.

٢. يمكن زيادة محصول الحبوب بزراعة الهجن الفردية البيضاء ١٠ ,٢٢ والهجين الفردي الأصفر ١٥٥ وكذلك الهجن الثلاثية البيضاء ٣٢١ ,٣٢٢ والهجين الثلاثي الأصفر ٣٥٢ حيث تتميز هذه الهجن بالقيم العالية لمعدلات النمو الخضري ومحصول الحبوب ومكوناتة وكذلك مكونات التمثيل الضوئي المؤدية الي أفضل محصول اقتصادى وذلك مقارنة بالثمانية هجن البيضاء و الصفراء الأخرى في هذه الدراسة.