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Partition and Migration of Photosynthates in Eight Promising Yellow Maize Hybrids Grown in Newly Cultivated Sandy Land

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ABSTRACT

Two field experiments were carried out in newly cultivated sandy land at private farm, in New Salheyia Region, El-Sharkeiya Governorate, Egypt in the summer seasons of 2013 and 2014 to study partition and migration in eight promising yellow maize hybrids. Results can be summarized as follows :

Yellow maize hybrids significantly differed in growth characters at the different stages of growth and yield and its components.

The eight yellow maize hybrids under study, i.e S.C. 168, S.C. 173, S.C. 176, S.C. 177, T.W. 352, T.W. 353, T.W. 354 and T.W. 360 differed significantly in photosynthates partitioning; where; significant differences were found in carbohydrate and protein percentages in vegetative organs, kernels and straw, as well as, in oil percentage in kernel. Moreover, the hybrids differences in glucose required for synthes of different chemical constituents of each vegetative organs, kernels and straw, as well as, carbon equivalent in these eight promising yellow maize hybrids. Furthermore, hybrid differences in yield energy per plant and/or per fed. for kernels and straw yields ; as well as ; for energy coefficient of crop index were significant.

Highly significant and positive simple correlation coefficient were found between kernels yield/plant and each one of No. of ears/plant, ear length, ears dry wt./ plant, No. of rows/ear, No. of kernels/row, RPP_{kr} and 4^{th} leaf blade area. On the contrary, highly significant and negative relationship were found between kernels yield and plant height and RPP_{veg}.

No. of ears/plant, No. of kernels/row, ears dry wt./plant, plant height, ear length and 4^{th} leaf blade area were the most effective in contributing to kernels yield since R^2 was 96.6% of the total variation.

It is worthy to mention that harvested yellow maize yield can be increased by growing S.C. 168, S.C. 173, S.C. 176, S.C. 177, T.W. 354 and T.W. 360 that characterized by highest efficiency in partitioning of photosynthates towards economic yield (kernels yield).

Key words: Yellow maize hybrids, partition, migration, Sandy Land

Introduction

The introduction of single crosses, i.e. S.C. 168, S.C. 173, S.C. 176 and S.C. 177, and the three-way crosses, i.e. T.W. 352, T.W. 353, T.W. 354 and T.W. 360 of yellow maize hybrids, has resulted in an increased yielding ability when grown under modern production techniques. The yield potential of yellow maize hybrids can be defined as the total biomass produced or the agricultural important part of the corn (i.e. kernels yield). The total biomass is a results of the integration of metabolic reaction of the plant. Consequently, any factor influencing the metabolic activity of the plant at any period of its growth can affect the yield. Metabolic processes in yellow maize plants are greatly governed by both internal, i.e. genetic make up of the plant and external conditions which involve the main factors namely climatic and edaphic environmental factors. Yield potential of yellow maize could be regulated through alternation of genetical make up and reconstitution of genetical structure through breading program and/or by modificantion of environment through improving cultural treatment. However, Egyptian Yellow Maize Hybrids may differ in their assimilating capacity and distribution could be referred to as Source and Sink relation.

The objective of this study was to investigate partition and migration of photosynthatsis in eight promising yellow maize hybrids (*Zea mays* L.) grown in newly cultivated sandy land. In this study, the growth and development of the plant was studied at fifteen days intervals starting from 75 to 105 days after sowing to determine how the yield components developed. It is hoped that through our results, area of possible improvement may be shown which could help plant breeder in the development of future higher yielding yellow maize hybrids under newly cultivated sandy land conditions.

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Materials and Methods

Yellow maize hybrids, i.e. the four single crosse, i.e. S.C. 168, S.C. 173, S.C. 176 and S.C. 177, and the four three-way crosses, i.e. T.W. 352, T.W. 353, T.W. 354 and T.W. 360 were cultivated in two field experiments in newly cultivated sandy land at private farm in New Salheya Region, El-Sharkeiya Governorate, Egypt during 2013 and 2014 summer seasons to investigate partition and migration of photosynthates in eight promising yellow maize hybrids (*Zea mays* L.) in a complete randomized black design with six replications. Three replications was adapted for vegetative growth studies and the rest for yield and its components. Plot size was seven ridges, five meter long and 60 cm apart. Planting was done at Mide May in the two seasons in hills spaced 25cm along. Three kernels per hill. Thinning to plant per hill was done at 21 days after planting. Nitrogen fertilizer was applied at a rate of 120 kg N/fed. in three equal doses at 21, 28 and 35 days after planting before irrigation. Irrigation, pest control, and other cultural practices were carried out as recommended. Simples 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 leaves and ears/plant, dry weight of each one of stemt+sheats , blades and ears “g/plant”. In addition, flag leaf blade, 4th leaf blade area and blades area “cm^2/plant” were calculated according to Bremner and Taha (1966) and leaf area index (LAI) as Watson (1952). At harvest, ten guarded plants were taken at random from the middle two ridges of each plot to determine yield and yield components, i.e. plant height, stem diameter, ear diameter “cm”, ear length “cm”, number of ears/plant, ear dry weight/plant, number of rows/ear, number of kernels/row, kernels, straw and biological yields per plant. In addition, kernels, straw and biological yield “ton/fed.” were determined from other three middle ridges for each plot and then converted to yield per fed., where, crop index, harvest and migration coefficient were estimated according to Abdel-Gawad *et al.* (1987). Relative photosynthetic potential (RPP), for kernels and biological yield “g/LAI”, as well as, vegetative organs were calculated according to the method described by Vidovic and Pokorny (1973), where $RPP_{kr} = K_r$ per plant/LAI, $RPP_{bio} = Y_{bio}$ per plant/LAI and $RPP_{veg} = RPP_{bio} – RPP_{kr}$.

To study photosynthate partitioning in the previous eight yellow maize hybrids crop growth rate (CGR mg/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 and straw, as well as, oil in kernels. Although plant composition changes with age, these values may be fairly enough to provide an estimate of the partitioning coefficient. 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 factors to estimate carbon equivalent, production value, glucose required for synthesis, stored gram atoms, work carbon required in synthesis for carbohydrate protein and oil in the different plant components was used as reported by Hanson *et al.* (1960), 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 method described by Dubios *et al* (1956), meanwhile, total nitrogen % and crude oil (%) were determined according to A.O.C.S (1980). Total nitrogen % was multiplied by 6.25 to calculates protein (%). The energy yield per plant and per feddan at harvest was calculated using caloric conversion factors according to Hanson *et al* (1960).

Combined analysis was made for the two growing seasons as results followed similar results according to Snedecor and Cochran (1990). For comparison between means, L.S.D. test at 5% level was used.

Simple correlation coefficient for all possible combination between kernels plant yield and means of some characters studied after anthesis (90 days after planting) and some yield components were practiced according to Neter Wasserman (1974). Simple correlation of cource do not permit the estimation of the direct effect of particular yield factor such as plant height, ears dry weight/plant, number of kernels/row, RPP_{kr}, RPP_{bio}, RPP_{veg} and flag leaf area since these variables are in some ways associated with yield. Therefore, the path coefficient analysis which measures the direct influence of an variable upon another and permits the separation of the simple correlation into of direct and indirect effects was done according to Wright (1934) and Snedecore and Coachran (1990).

Results and Discussion

Hybrid differences in growth characters:

Hybrid differences were found among the eight yellow maize hybrids under study, i.e. S.C. 168, S.C. 173, S.C. 176 and S.C. 177, and the three-way crosses, i.e. T.W. 352, T.W. 353, T.W. 354 and T.W. 360 in growth characters, i.e. plant height, number of active leaves/plant, number of ears/plant, blades dry weight “g/plant”, stem + sheats dry weight “g/plant”, ears dry weight “g/plant”, flag leaf blade area, 4th leaf blade area, blades area “cm^2/plant” and LAI after 75, 90 and 105 days after sowing were recorded in Table (1). Furthermore, the hybrid differences in the previous growth characters were significant at 75, 90 and 105 days after sowing, also, number of active leaves/plant, blades dry weight/plant, stem + sheats dry weight/plant, flag leaf blade area, 4th leaf blade area, blade area/plant and LAI tented to increase with advance of plant age up to 90 days after sowing and thereafter decreased, whereas, plant height, number of ears/plant and ears dry weight/plant tended to increase with advance of plant age up to 105 days after sowing (Table, 1).

The hybrid differences herene in growth characters are in good agreement with the results obtained by Zaki *et al* (1999), Ahmed and Hassanein (2000), Keleinhez (2003), Sadek *et al* (2006 a), Mirdad (2010), Saleh *et al* (2011), Ahmed *et al* (2011) and Abouzeina *et al* (2013). In addition, the hybrid differences in growth characters under this study may be due to the differences in genetic structure and the hybrid differences in glucose requires for synthesis of different chemical constituents in different plant organs, in carbon equivalent and partitioning of photosynthates among the plants (Zaki *et al,* 1999, Ahmed and Hassanein, 2000, Sadek *et al,* 2006 b, Saleh *et al,* 2011 and Ahmed *et al*, 2011), also, to the great differences between genotypes in mineral element concentration (Clarch *et al*, 1997 and Abo El-Seoud and Wafaa, 2010). On the other hand, the inconstant decline in stem + sheats dry weight/plant, blades dry weight/plant, and the inconstant increament in ears dry weight/plant caused after 90 days from sowing may be due to the hybrid differences in photosynthates partitioning (Zaki *et al*, 1999, Ahmed and Hassanein, 2000, Sadek *et al*, 2006 b, Saleh *et al*, 2011 and Ahmed *et al*, 2011.

Table 1: Hybrid differences in growth characters of eight yellow maize hybrids. (Average of 2013 and 2014 seasons).

Plant age	S.C 168	S.C 173	S.C 176	S.C 177	T.W 352	T.W 353	T.W 354	T.W 360	L.S.D at 5% level
	Plant height "cm"								
75	218.6	217.92	215.2	201.68	230.24	225.4	225.40	216.00	4.64
90	240.56	236	229.1	227.21	251.43	245.91	243.10	240.0	3.36
105	251.60	249.0	254.0	240.30	277.79	246.5	256.65	255.95	4.66
	No. of active leaves/plant								
75	17.10	16.5	17.00	17.05	17.71	17.64	17.20	17.00	0.04
90	16.7	17.5	17.50	18.5	19.00	17.67	17.5	17.50	0.35
105	13.00	13.75	15.00	15.75	16.00	15.33	15.00	15.0	0.23
	No. ears/plant								
75	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	n.s
90	1.16	1.10	1.23	1.37	1.10	1.10	1.10	1.2	0.08
105	1.25	1.25	1.30	1.50	1.17	1.17	1.25	1.25	0.04
	Blades dry wt. "g/plant"								
75	19.57	18.98	17.46	17.75	21.78	20.74	23.79	21.06	0.78
90	22.82	22.69	21.87	21.39	25.68	23.27	23.99	22.51	0.85
105	17.16	16.38	15.73	15.34	21.45	18.75	20.28	19.77	0.98
	Stem + sheats dry wt. "g/plant"								
75	44.22	44.02	42.71	37.29	49.56	47.54	45.88	44.75	1.44
90	55.83	56.55	55.22	51.19	62.93	60.77	57.19	56.33	2.03
105	47.14	48.54	47.70	43.90	51.51	49.00	48.66	47.21	1.92
	Ears dry wt. "g/plant"								
75	23.67	24.93	26.13	28.55	21.78	22.59	22.83	22.80	0.63
90	103.36	111.44	99.76	126.64	93.84	96.56	97.84	98.20	0.84
105	145.64	154.23	161.50	162.87	134.16	138.23	138.99	139.20	1.22
	Flag leaf blade area "cm^2"								
75	97.24	123.59	131.16	140.34	93.25	106.8	109.14	103.62	5.21
90	139.60	148.41	157.42	168.82	134.47	134.47	141.27	142.38	1.58
105	134.98	138.13	139.85	149.74	124.36	121.21	136.94	139.47	2.62
	4th leaf blade area "cm^2"								
75	391.84	410.08	420.96	433.20	391.84	386.8	371.63	371.04	5.04
90	427.36	433.04	447.28	451.92	441.28	426.24	399.84	421.00	3.05
105	402.64	407.59	416.88	428.80	381.92	378.8	368.05	385.00	2.63
	Blade area "cm^2/plant"								
75	3886.69	3860.0	3778.59	3715.18	4390.59	4162.2	4050.25	3897.59	6.68
90	4390.0	4385.00	4360.50	4263.77	5113.6	4756.18	4736.71	4694.89	7.39
105	4218.0	4169.0	4137.0	4016.00	4663.93	4422.2	4599.4	4428.25	2.01
	Leaf area index (LAI)								
75	2.59	2.57	2.52	2.48	2.93	2.77	2.7	2.60	0.03
90	2.93	2.92	2.91	2.84	3.4	3.17	3.16	3.13	0.09
105	2.81	2.78	2.76	2.68	3.11	2.95	3.07	2.95	0.05

Hybrid differences in yield and its components:

The results illustrated in Table (2) showed significant differences among the eight yellow maize hybrids under study, i.e. the four single crosses S.C. 168, S.C. 173, S.C. 176 and S.C. 177 and the four three-way crosses T.W. 352, T.W. 353, T.W. 354and T.W. 360 in yield and its components, i.e. plant height, stem diameter, ear diameter, ear length, number of ears/plant, ears dry weight/plant, number of rows/ear, number of kernels/row, RPP_{kr}, RPP_{bio}, RPP_{vveg},, kernels; straw and biological yield/plant and/or per fed., migration coefficient, crop index and harvest index. Moreover, data reported in the same table observed that T.W. 352 significantly surpassed other seven yellow maize hybrids under study in each of plant height, stem diameter, ear diameter, ear length, ear dry weight/plant, straw yield/plant and/or fed., and biological yield/plant, whereas, S.C. 17 had the highest significant values from number off ears/plant, number of rows/ear, number of kernel/row, RPP_{kr},, RPP_{bio}, kernels yield/plant and/or per fed.., biological yield/fed., crop index and harvest index compared with other seven hybrids under study. On the other hand, S.C. 353 characterized by significant heights value from RPP_{veg}, meanwhile, S.C. 176 gave the greatest significant value from migration coefficient in comparison with other hybrids under study (Table 2).

Table 2: Hybrid differences in yield and its components of eight yellow maize hybrids. (Average of 2013 and 2014 seasons).

Hybrids / Yield components	S.C *168*	S.C *173*	S.C *176*	S.C *177*	S.C *352*	T.W *353*	T.W *354*	T.W *360*	L.S.D at 5% level
Plant height "cm"	250.0	248.0	246.0	242.33	280.25	266.5	259.7	260.0	4.01
Steam diameter "cm"	2.82	2.64	2.74	2.74	3.06	3.04	2.86	2.82	0.02
Ear diameter "cm"	5.90	5.75	5.56	5.68	6.02	5.81	5.62	5.70	0.07
Ear length "cm"	28.5	29.10	29.84	30.55	32.05	30.92	30.84	31.00	0.67
No. of ears/plant	1.25	1.25	1.30	1.50	1.17	1.17	1.25	1.25	0.04
Ears dry wt. "g/plant"	285.0	290.0	287.90	288.40	293.58	284.0	288.5	289.3	1.59
No. of rows/ear	15.60	15.75	15.85	16.00	15.60	15.60	15.70	15.70	0.15
No. of kernels/row	47.00	47.50	48.70	49.25	45.74	46.0	46.75	47.00	0.33
RPP_{kr} "g/LAI"	65.62	68.65	70.73	78.76	51.47	56.24	57.76	60.62	3.14
RPP_{bio} "g/LAI"	157.26	154.96	152.60	159.69	143.82	150.28	148.90	148.16	1.60
RPP_{veg} "g/LAI"	91.64	86.31	81.87	80.93	92.35	94.04	91.14	87.54	1.49
Kernels yield "g/plant"	192.26	200.47	205.83	223.68	175.0	178.28	182.52	189.75	9.15
Straw yield "g/plant"	268.50	252.00	238.24	229.84	314.0	298.10	288.00	274.00	11.47
Biological yield "g/plant"	460.76	452.47	444.07	453.52	489.0	476.38	470.52	463.75	6.02
Migration coefficicent	0.62	0.64	0.65	0.64	0.60	0.60	0.61	0.62	0.01
Kernels yield "ton/fed."	4.10	4.20	4.26	4.48	3.90	3.95	3.99	4.10	0.16
Straw yield "ton/fed."	4.71	4.47	4.54	4.41	4.94	4.54	4.62	4.54	0.18
Biological yield "ton/fed"	8.81	8.67	8.80	8.89	8.84	8.49	8.61	8.64	0.03
Crop index	0.47	0.48	0.48	0.50	0.44	0.47	0.46	0.47	0.02
Harvest index	0.87	0.94	0.94	1.02	0.79	0.87	0.86	0.90	0.10

Hybrids differences in yield and its components of this study may be due attributed to differences in genetic structure between the eight yellow maize hybrids, S.C. 168, S.C. 173, S.C. 176, S.C. 177, T.W. 352, T.W. 353, T.W. 354 and T.W. 360, also, to the hybrid differences in growth characters (Table 1) and to the hybrid differences in photosynthates partitioning that recorded in the following part of this study (Tables 3 and 4), that previously indicated by Zaki *et al*, (1999), Ahmed and Hassanein, (2000), Sadek *et al*, (2006 b), Saleh *et al*, (2011) and Ahmed *et al*, (2011). In addition, the widely differences between maize genotypes for mineral concentration that found by Clorch *et al* (1997) and Abou El-Seoud and Wafaa (2010) can be attribute the hybrid differences in yield and its components. Moreover, the significant superiority of T.W. 352 in straw yield/plant and/or per fed. and biological yield/plant over other seven yellow maize hybrids under study may be due to its greatest values from plant height, stem diameter, ear diameter, ear length, ears dry weight/plant, and to the lowest kernels yield/plant, where as, the enferiority of three way crosses than single crosses S.C. 168, S.C. 173, S.C. 176 and S.C. 177 in kernels yield/plant and/or per fed. may be due to the lowest value from number of rows/ear, number of kernels/row, RPP_{ke}, RPP_{bio}, migration coefficient, crop index and harvest index that recorded by the three way crosses compared with single crosses (Table 2). It is worthy that the high yielding cultivar had amore vigorous system for generating reduction potentials during plant growth than did the less productive cultivar and higher yielding cultivars has a higher photosynthetic electron transport chain potential, which is a genetically character, more than lower yielding cultivar (Pucridge, 1971). Another factor may be a cause of the highest kernels yield per plant and/or per fed. are the maximum number of rows/ear and number of kernels/row that harvested by single crosses (Table 2). The important of number of kernels is suggested by increases in number of kernels per unit area of land that have accompanied that recent increase in yield showed by new cultivars (Pendelton *et al*, 1968).

Hybrid differences in yield and its components in this study area agreement with the results obtained by Zaki *et al*, (1999), Ahmed and Hassanein, (2000), Sadek *et al*, (2006 b), Saleh *et al*, (2011) and Ahmed *et al*, (2011).

Photosynthate Partitioning :

The partitioning coefficient would be determined by the capacity of the photosynthetic sink related by ear. When plants reached the final weeks of the filling period (soft stage to ripe study), the coefficient of portioning may increase evidence for these is shown by very rapid decline in the vegetative plant parts. There were significant differences between yellow maize hybrids in crop growth rate (Table 3) and ears dry weight/plant at different stages of growth (Table 1). In addition S.C. 177 significantly out weighted the other seven yellow hybrids in crop growth rate (Table 3), and in ear dry weight/plant (Table 1). Again, crop growth rate tended to increase with advancing age up to 90 days and then declined with advancing age from 90 to 105 days after sowing (Table 3). On the contrary ears dry weight/plant tended to increase lineary from 75 days of ter planting (Table 1). Furthermore, CGR values of vegetative organs reflect the total amount of photosynthate partitioning into the yield components. The partitioning coefficient can not be approximated from a simple ratio of the slope of crop growth rate since more photosynthated is required to produce a given amount of kernels than the same amount of vegetative material. The additional photosynthate is required to produce the additional protein and oil in kernels (Hanson *et al.*, 1960, Penning De Vries *et al,* 1974, Mc Graw, 1977, Saleh *et al*, 2011 and Ahmed *et al*, 2011).

To estimate the amount of photosynthate needed to produce a quantity of ears in the same quantity of vegetative material, the relative quantities of carbohydrate, protein and oil should be detected. Significant differences were found among the eight yellow maize hybrids in carbohydrate and protein of vegetative organs, kernels and straw, as well as, oil of kernels (Table 3). In addition, S.C. 168 significantly surpassed the other seven yellow hybrids S.C. 173, S.C. 176, S.C. 177, T.W. 352, T.W. 353, T.W. 354 and T.W. 360 in protein percentage of vegetative organs, carbohydrate % of kernels and straw and in oil % of kernels, whereas, S.C. 177 harvested the highest significant values in carbohydrate % of vegetative organs, as well as, protein percentage of kernels and straw compared with other hybrids under study (Table 3).

Table 3: Hybrid differences in chemical constituent, glucose required for synthesis and carbon equivalent for vegetative parts, kernels and straw of eight yellow maize hybrids. (Average of 2013 and 2014 seasons).

Characters \ Hybrids	S.C 168	S.C 173	S.C 176	S.C 177	S.C 352	T.W 353	T.W 354	T.W 360	L.S.D at 5% level
	Carbohydrate, protein and oil								
Vegetative organs									
Carbohydrate	79.83	79.50	79.56	79.66	78.62	78.80	78.87	78.94	0.19
Protein	10.09	9.80	9.35	9.46	9.17	9.25	9.37	9.45	0.17
Kernels									
Carbohydrate	81.59	81.26	81.30	81.44	79.80	79.95	80.47	80.95	0.07
Protein	10.85	10.78	10.83	10.90	10.65	10.63	10.68	10.70	0.04
Oil	3.09	3.05	3.00	3.06	2.82	2.85	2.89	2.94	0.02
Straw									
Carbohydrate	82.60	81.50	81.70	82.25	80.93	80.98	81.43	81.00	0.30
Protein	9.34	9.41	9.55	9.60	9.32	9.30	9.32	9.35	0.05
	Glucose required for carbohydrate, protein and oil synthesis								
Vegetative organs									
Carbohydrate	0.936	0.932	0.933	0.933	0.922	0.924	0.925	0.925	0.003
Protein	0.163	0.158	0.151	0.153	0.148	0.143	0.151	0.152	0.005
Kernels									
Carbohydrate	0.957	0.935	0.953	0.955	0.936	0.937	0.943	0.949	0.002
Protein	0.175	0.174	0.175	0.175	0.172	0.171	0.172	0.173	n.s
Oil	0.088	0.087	0.085	0.087	0.080	0.081	0.082	0.084	n.s
Straw									
Carbohydrate	0.968	0.955	0.958	0.964	0.949	0.949	0.955	0.950	0.003
Protein	0.151	0.152	0.154	0.155	0.150	0.15	0.150	0.151	0.001
	Carbon equivalent								
Vegetative organs									
Carbohydrate	31.93	31.8	31.824	31.84	31.448	31.55	31.5487.378	31.576	0.055
Protein	7.945	7.717	7.362	7.449	7.22	7.283		7.441	0.02
Kernels									
Carbohydrate	32.64	32.504	32.52	32.576	31.92	31.98	32.188	32.38	0.006
Protein	85.43	8.488	8.528	8.583	8.386	8.371	8.409	8.425	0.029
Oil	3.511	3.466	3.41	3.477	3.205	3.239	3.284	3.341	0.017
Straw									
Carbohydrate	33.04	32.6	32.68	32.90	32.37	32.392	32.572	32.4	0.09
Protein	7.354	7.409	7.52	7.557	7.339	7.323	7.339	7.362	0.004
	Crop growth rate (C.G.R. mg/cm^2/day)								
At 65 – 80 days after sowing	9.44	9.6	9.72	9.81	7.78	7.89	7.02	8.15	0.06
At 65 – 80 days after sowing	7.29	7.31	7.48	7.56	6.41	6.65	6.87	7.03	0.08

Data reported in Table (3), indate clearly that glucose required for synthesis of the chemical compounds by the various yellow maize hybrids components. Differences between yellow maize hybrids in glucose required for synthesis of carbohydrate in vegetative organs, kernels and straw of protein in vegetative organs, as well as, between hybrids in glucose required for synthesis of oil in kernels. Moreover, S.C. 168 have the highest significant values from glucose required for synthesis of carbohydrate and protein in vegetative organs and of carbohydrate in kernels and straw, meanwhile, S.C. 177 gave the highest significant value from glucose required for synthesis of protein in straw compared with other seven yellow hybrids under study.

Regarding, the carbon equivalent, according to Hanson *et al* (1960) carbon equivalent is defined the gram atoms of sugar of sugar carbon required to produce product including both gram atoms of work carbon lost in the synthesis and gram atom of carbon stored in the product. Data reported is Table (3) revealed that significant differences between yellow maize hybrids in carbon equivalent for each carbohydrate and protein of vegetative organs, kernels and straw, as well as, for oil in kernels. Generally, S.C. 168 had the highest values from carbon equivalent for carbohydrate of vegetative organs, kernels and straw and for protein in vegetative organs and for oil in kernels, meanwhile, S.C. 177 gave the greatest values from carbon equivalent for protein in straw in comparison with other hybrids under study.

Table (4) observed that there were significant differences among the tested eight yellow maize hybrids in yield energy per plant and/or per fed., where maize cultivars were significantly differed in energy yield for carbohydrate, protein and oil. Furthermore, S.C. 177 significantly exceeded the other seven yellow hybrids under study in energy yield of carbohydrate, protein and oil and total energy yield of kernels per plant and/or per fed., whereas, T.W. 352 significantly outweighed other hybrids studied in energy yield of carbohydrate, protein and total energy of straw per plant and/or per fed. In addition; S.C. 177; also; characterized by its superiority from energy coefficient of crop index and harvest index compared with S.C. 168, S.C. 173, S.C. 176, S.C. T.W. 352, T.W. 353, T.W. 354 and T.W. 360 hybrids (Table 4). Thus, it is could be concluded that the present results are in harmony with the results obtained by Zaki *et al*, (1999), Ahmed and Hassanein, (2000), Sadek *et al*, (2006 b), Saleh *et al*, (2011) and Ahmed *et al*, (2011).

It worthy that as mentioned before, harvested yellow maize yield can be increased by growing S.C. 168, S.C. 173, S.C. 176, S.C. 177, T.W. 354 and T.W. 360 that characterized by highest efficiency in partitioning of photosynthates towards economic yield (kernels yield).

Table 4: Hybrid differences in energy yield per plant and/or per feddan at harvest of eight yellow maize hybrids. (Average of 2013 and 2014 seasons**).**

Yield energy \ Hybrids	S.C 168	S.C 173	S.C 176	S.C 177	S.C 352	T.W 353	T.W 354	T.W 360	L.S.D at 5% level
	Yield energy/plant at harvest "cals"								
<u>Kernels</u>									
Carbohydrate	619.62	643.46	670.63	719.55	551.62	563.01	580.15	606.73	11.12
Protein	95.33	98.76	101.87	111.42	85.17	86.61	89.08	92.79	7.63
Oil	55.84	56.53	58.04	64.34	46.39	47.76	49.58	52.43	1.44
Total	770.79	798.75	830.54	895.31	683.18	697.38	718.81	751.96	20.76
<u>Straw</u>									
Carbohydrate	876.03	811.25	768.84	746.72	1003.8	953.53	927.03	876.66	11.59
Protein	114.61	108.37	103.98	100.84	133.74	126.7	122.67	117.08	4.50
Total	990.64	919.62	872.82	847.56	1137.54	1080.23	1049.7	993.74	1.64
	Yield energy/fed. at harvest "10^6 cals"								
<u>Kernels</u>									
Carbohydrate	13.21	13.48	13.68	14.41	12.29	12.47	12.68	13.11	0.25
Protein	2.03	2.07	2.11	2.23	1.90	1.92	1.95	2.00	0.08
Oil	1.19	1.20	1.20	1.29	1.03	1.06	1.08	1.13	0.05
Total	16.43	16.75	16.99	17.93	15.22	15.45	15.71	16.24	0.49
<u>Straw</u>									
Carbohydrate	15.37	14.39	14.75	14.33	15.79	14.52	14.86	14.53	0.18
Protein	2.01	1.92	1.98	1.93	2.10	1.93	1.97	1.94	0.04
Total	17.38	16.31	16.73	16.26	17.89	16.45	16.83	16.47	0.13
	Energy coefficient								
Energy coefficient of crop index	0.49	0.51	0.50	0.52	0.46	0.48	0.48	0.50	0.01
Energy coefficient of harvest index	0.95	1.03	1.02	1.10	0.85	0.94	0.93	0.99	0.04

Correlation studies :

Table (5) observed clearly that highly significant and positive simple correlation coefficient were found between kernels yield/plant and each of number of ears/plant, ear length, ears dry weight/plant, number of rows/ear, number of kernels/row, RPP_{kr} and 4th leaf blade area, between number of ear/plant and ear length, ear dry weight/plant, ear diameter, number of kernels/row and flag leaf blade area, between ear length and each of ear dry weight/plant, grain index, 4th leaf blade area and RPP_{kr}, as well as, ear dry weight and each one of number of rows/ear, number of kernels/row, RPP_{kr}, 4th leaf blade area and flag leaf blade area. Also, the relationships between ear diameter and each of grain index, RPP_{kr} and flag leaf blade area, between grain index and each of 4th leaf blade area and flag leaf blade area, between number of rows/ear and number of kernels/row and 4th leaf blade area and number of kernels/row and 4th leaf blade area and between 4th leaf blade area and flag leaf blade area and between flag leaf blade area and RPP_{kr} were positive and high significant (Table 5). On the contrary; highly significant and negative simple correlations were found between kernels yield/plant and each one of plant height and RPP_{veg}, between plant height and each of 4th leaf blade area, number of rows/ear, and number of kernels/row, between ear diameter and RPP_{bio}, between 4th leaf blade area and RPP_{veg}, between ear length and RPP_{bio} and RPP_{veg}, as well as, between number of rows/ear and RPP_{kr} and RPP_{bio} (Table 5). On the other hand, the correlation between plant height and ear diameter, grain index and RPP_{bio}, between number of ear/plant and RPP_{kr} and 4th leaf blade area, as well as, between stem diameter and ear diameter were positive and significant (Table 5). On the contrary a negative and significant simple correlation were found between RPP_{bio} and each one of kernels yield/plant, ear dry weight/plant, ear diameter, number of kernels/row, RPP_{kr} and 4th leaf blade area, between RPP_{veg} and number of ears/plant, between flag leaf blade area and 4th leaf blade area, between RPP_{kr} and each of RPP_{bio} and RPP_{veg} between grain index and number of rows/ear (Table 5). In adition, ther were positive and insignificant correlations between kernels yield/plant and each one of stem diameter, ear diameter, grain index, and flag leaf blade area, between plant height and each of stem diameter, flag leaf blade area, RPP_{kr} and RPP_{veg}, between number of ears/plant and stem diameter, grain index and number of rows/ear, as well as, between stem diameter and each one of ear length, grain index, flag leaf blade area, RPP_{kr} and RPP_{bio}. Also, the relationships between ear length and each of ear diameter and 4th leaf blade area, between ears dry weight/plant and ear diameter and grain index, between flag leaf blade area and each of number of rows/ear and number of kernels/row, as well as, between RPP_{bio} and RPP_{veg} were positive and insignificant (Table 5).

Moreover, the simple correlation coefficient for the rest possible combinations between kernels yield and previous measurements were negative and insignificant.

Table 5 : Simple correlation coefficient between kernels yield and some yield components and growth characters in eight yellow maize hybrids.

Characters		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
Kernels yield "g/plant"		-0.53**	0.72**	0.06	0.55**	0.95**	0.27	0.09	0.41**	0.52**	0.73**	0.27	0.47**	-0.33*	-0.46**
Plant height "cm"	X_1		-0.23	0.14	-0.22	-0.57**	0.33*	0.38*	-0.43**	-0.60**	-0.70**	0.30	0.06	0.32*	0.30
No. of ears/plant	X_2			0.22	0.57**	0.71**	0.52**	0.30	0.04	0.50**	0.39*	0.42**	0.38*	-0.16	-0.35*
Stem diameter "cm"	X_3				0.07	-0.11	0.34*	0.33*	-0.16	0.07	-0.02	0.03	0.04	0.29	-0.06
Ear length "cm"	X_4					0.57**	0.23	0.45**	-0.07	-0.07	0.01	0.62**	0.69**	-0.44**	-0.57**
Ears dry wt. "g/plant"	X_5						0.26	0.08	0.43**	0.47**	0.79**	0.44**	0.49**	-0.37*	-0.46**
Ear diameter "cm"	X_6							0.68**	-0.19	-0.08	-0.16	0.41**	0.56**	-0.37*	-0.13
Seed index	X_7								-0.36*	-0.29	-0.15	0.45**	0.53**	-0..11	-0.07
No. of rows/ear	X_8									0.59**	0.44**	0.02	-0.65**	-0.39*	-0.21
No. of kernels/row	X_9										0.50**	0.01	-0.19	-0.15	-0.18
4th leaf blade area	X_{10}											0.41**	-0.21	-0.38*	-0.49**
Flag leaf blade area	X_{11}												0.63**	-0.37*	-0.03
RPP_{kr}	X_{12}													-0.34*	-0.38*
RPP_{bio}	X_{13}														0.29
RPP_{veg}	X_{14}														

Path coefficient analysis:

Table (6), observed the partitioning of average simple correlation coefficient between kernels yield/plant and each of plant height, number of ears/plant, ear length, ear dry weight/plant, number of rows/ear, number of kernels/row, 4th leaf blade area, RPP_{kr} and RPP_{bio} as the average of the eight yellow maize hybrids under study. No. of ears/plant proved to have a high direct effect on kernels yield/plant compared with that of number of rows/ear, 4th leaf blade area and RPP_{veg}. No. of kernels/row had a high negative direct effect on kernels yield compared with ears dry weight/plant, plant height, ear length and RPP_{kr} since the average mean of direct effect was 15.99, 7.86, 2.65, 0.04, -13.62, -10.91, -8.05, -4.25 and -0.78 for those nine characters, respectively (Table 6). Again as mentioned before (Table 1), total correlation coefficient was most pronounced in ears dry weight/plant ($r = 0.95$), than in 4th leaf blade area ($r = 0.73$), number of ears/plant ($r = 0.72$), ear length ($r = 0.55$), number of kernels/row ($r = 0.52$), RPP_{kr} ($r = 0.47$), number of rows/ear ($r = 0.41$), RPP_{veg} ($r = 0.46$) and plant height ($r = -0.53$).

Table (7) shows that the direct effect of number of ears/plant was 10.47 of the variation being higher than that of number of kernels/row (9.18 %), ears dry weight/plant (4.48 %), plant height (2.63 %), number of rows/ear (2.50 %), ear length (0.74 %), 4th leaf blade area (0.28 %), RPP_{kr} (0.02 %) and RPP_{veg} (0.001 %) of the variation, respectively. The joint effect of number of ears/plant with plant height, ear length, ears dry weight/plant, number of rows/ear, number of kernels/row, 4th leaf blade area, RPP_{kr} and RPP_{bio} amounted to 2.43, 3.25, 0.42, 9.80, 1.73, 0.40, 0.10 and 2.22 % of the variation respectively. The joint effect of ear length with plant height, ears dry weight/plant, number of rows/ear, number of kernels/row, 4th leaf blade area, RPP_{kr} and RPP_{veg} formed 0.64, 0.20, 9.93, 0.36, 0.01, 0.18 and 0.10 % of the variation respectively. Values of the joint effect of ears dry weight/plant with plant height, number of rows/ear, number of kernels/row, 4th leaf blade area,

RPP_{kr} and RPP_{bio} were 4.10, 3.06, 6.39, 1.89, 0.35 and 0.02 % of the variation, respectively. Furthermore, the joint effect of number of rows/ear with plant height, number of kernels/row, 4th leaf blade area, RPP_{kr}, RPP_{bio} had 2.52, 5.84, 0.76, 0.01 and 0.01 % of the variation, respectively, whereas, the joint effect of number of kernels/row with plant height, 4th leaf blade area, RPP_{kr} and RPP_{bio} was 6.09, 2.16, 0.78 and 0.01 % of the variation, respectively. In addition the joint effect of 4th leaf blade area with plant height, RPP_{kr} and RPP_{bio} amounted to 1.25, 0.03 and 0.01 %, respectively; meanwhile, the joint effect RPP_{kr} with plant height and RPP_{veg} was 0.04 and 0.001 % of the variation, respectively.

As mentioned before, number of ears/plant, number of kernels/row, ear dry weight/plant, plant height, ear length and 4th leaf blade area were the most effective in contributing to kernels yield since R^2 was 96.6 % of the total variation.

Table 6 : Path coefficient analysis of simple correlation coefficient of eight yellow analysis hybrids

Partitioning of simple correlation coefficient					
Source	Correlation	Source	Correlation	Source	Correlation
Kernels yield via. Plant height		Kernels yield via. ears dry wt./plant		Kernels yield via. 4th leaf blade area	
Direct effect Indirect via. No. of ears/plant Indirect via. ear length Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	-8.05 -3.83 0.98 6.44 -3.46 9.33 -1.90 -0.05 0.01 -0.53	Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via ear length Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	-10.91 4.75 11.66 -2.51 3.45 -7.21 2.14 -0.40 -0.02 0.95	Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via ear length Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	2.65 5.81 6.39 -0.04 -8.84 3.54 -8.58 -0.17 -0.03 0.73
Kernels yield via. No. of ears/plant		Kernels yield via. No. of rows/ear		Kernels yield via. RPP_{kr}	
Direct effect Indirect via. plant height Indirect via. ear length Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	15.99 1.94 -2.50 -7.93 0.36 -7.81 0.99 -0.30 -0.02 0.72	Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via ear length Indirect via. ear dry wt./plant Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	7.86 3.54 0.64 0.30 -4.60 -8.48 1.19 -0.03 -0.01 0.41	Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via ear length Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{veg} Total	-0.78 -0.48 6.22 -3.03 -5.57 0.52 3.01 0.58 -0.02 0.47
Kernels yield via. ear length		Kernels yield via. No. of kernels/row		Kernels yield via. RPP_{veg}	
Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	-4.25 1.85 9.42 -6.45 -0.56 1.06 0.03 -0.52 -0.03 0.55	Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via ear length Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Indirect via. RPP_{veg} Total	-13.21 5.00 4.45 0.30 -3.23 4.79 1.78 0.65 -0.01 0.52	Direct effect Indirect via. plant height Indirect via. No. of ears/plant Indirect via ear length Indirect via. ear dry wt./plant Indirect via. No. of rows/ear Indirect via. No. of kernels/row Indirect via. 4th leaf blade area Indirect via. RPP_{kr} Total	0.04 -2.49 -5.75 2.51 5.13 -1.73 2.86 -1.33 0.30 -0.46

Table 7: Direct and joint effects of some yield components and growth characters as percentage of yield variation in eight yellow maize hybrids.

Characters	Coefficient of determination	Percentage contribution	Characters	Coefficient of determination	Percentage contribution
Plant height "cm"	66.82	2.63	No. of ears/plant x 4^{th} leaf blade area	-9.91	0.40
No. of ears/plant	263.76	10.47	No. of ears/plant x RPP_{kr}	-0.64	0.01
Ear length	18.65	0.74	No. of ears/plant x RPP_{veg}	56.44	2.22
Ear dry wt./plant	122.68	4.38	Ear length x Ear dry wt./plant	4.82	0.20
No. of rows/ear	63.66	2.50	Ear length x No. of rows/ear	-252.63	9.93
No. of kernels/row	233.32	9.18	Ear length x No. of kernels/row	-9.23	0.36
4^{th} leaf blade area	7.23	0.28	Ear length x 4^{th} leaf blade area	-0.24	0.01
RPP_{kr}	0.42	0.02	Ear length x RPP_{kr}	4.76	0.18
RPP_{veg}	0.002	0.0001	Ear length x RPP_{veg}	0.21	0.01
Plant height x No. of ears/plant	63.60	2.43	Ear dry wt./plant x No. of rows/ear	-77.68	3.06
Plant height x Ear length	-16.27	0.64	Ear dry wt./plant x No. of kernels/row	162.51	6.39
Plant height x Ear dry wt./plant	106.91	4.10	Ear dry wt./plant x 4^{th} leaf blade area	-48.22	1.89
Plant height x No. of rows/ear	57.33	2.25	Ear dry wt./plant x RPP_{kr}	8.84	0.35
Plant height x No. of kernels/row	-154.9	6.09	Ear dry wt./plant x RPP_{veg}	0.43	0.02
Plant height x 4^{th} leaf blade area	31.76	1.25	No. of rows/ear x No. of kernels/row	-148.52	5.84
Plant height x RPP_{kr}	0.81	0.04	No. of rows/ear x 4^{th} leaf blade area	19.38	0.76
Plant height x RPP_{veg}	-0.16	0.01	No. of rows/ear x RPP_{kr}	0.44	0.02
No. of ears/plant x Ear length	-82.54	3.25	No. of rows/ear x RPP_{veg}	-0.15	0.01
No. of ears/plant x Ear dry wt./plant	10.55	0.42	No. of kernels/row x 4^{th} leaf blade area	-55.00	2.16
No. of ears/plant x No. of rows/ear	-249.12	9.80	No. of kernels/row x RPP_{kr}	-19.82	0.78
No. of ears/plant x No. of kernels/row	34.87	1.37	No. of kernels/row x RPP_{veg}	0.24	0.01
			4^{th} leaf blade area x RPP_{kr}	-0.63	0.03
			4^{th} leaf blade area x RPP_{veg}	-0.14	0.01
			RPP_{kr} x RPP_{veg}	0.03	0.001
R^2				0.958	96.60
Residual				0.042	3.40
Total				1.00	100.00

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