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Genetic Analysis Of Energy Production In Yellow Maize Hybrids Cultivated In Newly Cultivated Sandy Land

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Abstract: Two field experiments were carried out in newly cultivated sandy land at New Salheyia Region, Sharkia Governorate in summer seasons of 2008 and 2009 on nine yellow maize hybrids to study genetic analysis of energy production in yellow maize hybrids cultivated in newly cultivated sandy land. Results can be Summarized as follows :- Yellow maize hybrids significantly differed in growth parameters at the different stages of growth, as well as, in yield and its components. The nine yellow maize hybrids differed significantly in photosynthate partitioning, where significant differences were found in carbohydrate and protein percentages in vegetative organs; kernels and straw and oil percentage in kernels. In addition, glucose required for synthesis of different chemical constituents of each vegetative organs, kernels and straw, also, carbon equivalent was significantly differed among the nine yellow maize hybrids under investigation. Furthermore, hybrid differences in yield energy per plant and/or feddan for kernels and straw yields, as well as, above ground biomass and coefficient energy of harvest index were significant, whereas the difference in coefficient energy of crop index was insignificant. Highly significant and positive correlation was found between kernels yield/plant and each of ear diameter, ear length, number of ears/plant, ears dry weight/plant, number of rows/ear, number of kernels/row, RPP_{kr}, flag leaf blade area, 4^{th} leaf blade area, blades area/plant, LAI and migration coefficient, meanwhile, the correlation between kernels yield/plant and plant height, flag leaf angle and 4^{th} leaf area angle was negative and insignificant. The 4^{th} leaf blade area, ears dry wt. /plant, No. of rows/ear and No. of ears/plant could contribute much of yellow maize hybrids since R^2 was 99.85% of the variation. Harvested yellow maize yield can be increased by growing yellow single crosses (i.e. S.C. 161, S.C. 162, S.C. 155, S.C. 168 and Pioneer 3062) and the three way crosse T.W. 352 where, these hybrids characterized by their highest value from vegetative growth, yield and its components and photosynthates partitioning towards the economic yield compared with other three yellow maize hybrids under study.

Kew words: Genetic Analysis, Energy Production, Yellow Maize, Sandy Land

INTRODUCTION

The introduction of single crosses (i.e. S.C. 151, S.C. 152 and 155 and S.C. 161 and S.C. 162) and there way crosses (i.e. T.W. 351, T.W. 352 and Pioneer 3062) of yellow maize hybrids, has resulted in an increased yielding ability when growing under modern production techniques. The yield potential of yellow maize plant can be defined as the total biomass produced or the agricultural important part of the corn (i.e. kernel yield). The total biomass is a result 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 plant 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 modification of environment through improving cultural treatments. However, Egyptian yellow maize cultivars 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 genetic analysis of energy production in yellow mays (Zea

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mays L.) hybrids cultivated in newly cultivated land. In this study, the growth and development of the plant was studied at fifteen days intervals starting from 75 up 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 cultivar under newly cultivated sandy lands condition.

MATERIAL AND METHODS

Yellow maize hybrids, i.e. the seven single crosses (S.C. 151, S.C. 155, S.C. 161, S.C. 162, S.C. 168, S.C. Pioneer, 3062 and S.C. Pioneer 3084) and the two three way crosses (T.W. 351 and T.W. 352) were cultivated in two field experiments in newly cultivated sandy land at new Salheyia Region, Sharkia Governorate in summer seasons of 2008 and 2009 to study genetic analysis of energy production in yellow maize in a complete randomized block design with six replications. Three replications were adopted for vegetative growth studies and the rest for yield and its components. Plot size was seven ridges, five meters long and 60cm apart. Planting was done at 26^{th} May in the two seasons in hills spaced 25cm along, three kernels per hill. Thinning to one plant per hill was done at 21 days after planting. Nitrogen fertilizer was applied at a rate of 120kg 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. Samples of five guarded plants were taken at random for growth measurements and chemical analysis at 65, 80 and 95 days from planting. The following growth attributes were recorded ; plant height cm, number of active (green) leaves / plant, number of ears / plant, stem + sheats ; blades and ears dry weights / plant.

Furthermore, flag leaf blade, 4^{th} leaf blade and blades area / plant were calculated according to Bremner and Taha (1966) and leaf area index (LAI) as Watson (1952). In addition, flag leaf and 4^{th} leaf angles were recorded according to Pendleton *et al* (1968) between the leaf and stem.

At harvest, ten gnarded plants were taken at random from the middle two ridges of each plot to determine yield attributes, i.e. plant height "cm", stem diameter "cm", number of ears / plant, ears dry weight /plant, ear diameter "cm", ear length "cm", number of rows /ear, number of kernels /row, kernels and straw yields per plant .

Relative photosynthetic potential (RPP) for biological and kernels yields and vegetative organs was calculated according to the methods 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 yields were determined from the other three middle ridges for each plot, where crop index, harvest index and migration coefficient were estimated according to Abdel Gawad *et al* (1987).

To study photosynthate partitioning in the previous nine yellow maize hybrids ; crop growth rate (CGR mg / cm^2 / day) was determined by multiplaying NAR XLAI according to Abdel – Gawad *et al* (1987).

In addition, the percentage of carbohydrate and protein were estimated in vegetative organs; kernels and straw and oil in kernels. Although plants 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 factor 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 Abd El-Gawad *et al* (1987).

The total carbohydrate (%) in the different organs was determined according to the method shown by Dubios *et al* (1956). Total nitrogen (%) was determined according to A.O.C.S. (1980) and was multiplied by 6.25 to calculate protein (%). Curde oil (%) was determined using the method described by A.O.C.S (1980). In addition energy 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 (1982). For comparison between means, L.S.D test at 5% level was used.

Simple correlation coefficient for all possible combination between plant yield and means of some of the characters studied after anthesis (i.e. 90 days after planting) were practiced according to Neter and Wassermann (1974).

Simple correlation of course do not permit the estimation of the direct effect of particular yield factor such as plant height, number of ears / plant, blades area / plant and LAI or any other factor of yield, since this variable is in some way associated with one or more variable which in turn associated with yield . Therefore, the path coefficient analysis which measures the direct influence of one variable upon another and permits the separation of the simple correlation coefficient into components of direct and indirect effects, was done according to Wright (1934) and Snedecor and Cochran (1982).

RESULTS AND DISCUSSION

Growth Analysis:

The results reported in Table (1) showed significant differences among nine yellow maize hybrids under study, i.e. the seven single crosses S.C. 151, S.C. 155, S.C. 161, S.C. 162, S.C. 168, S.C. Pioneer 3062 and S. C. Pioneer 3084 and the two three way crosses T.W. 351 and T.W. 352 in growth parameters at 65, 80 and 95 days after sowing. Moreover, plant height, number of active leaves / plant, number of ears / plant, stem + sheats dry weight / plant, blades dry weight / plant, flag leaf blade area, 4^{th} leaf blade area, blades area / plant, and leaf area index for all hybrids tended to increase with advance of plant age up to 80 days after sowing and thereafter decreased, howerer, ears dry weight / plant, flag leaf angle and 4^{th} leaf angle tended to increased with advance of plant age up to 95 days after sowing .

It is worthy to mention that S.C. 161 gave the highest significant plant height, number of active leaves and ears / plant, ears dry weight / plant, flag leaf blade area, 4^{th} leaf blade area, blades area / plant and LAI, meanwhile, S.C. Pioneer 3084 had the greatest flag leaf angle, while, T.W. 352 gave the highest significant stem + sheats dry weight / plant, blades dry weight / plant, whereas, T.W. 351 produced the highest 4^{th} leaf angle compared with other yellow maize hybrids and the superiority was significant at the three different plant growth stages expect the differences between T.W. 351 and S.C. Pioneer 3084 in 4^{th} leaf angle failed to reach the significant level at 0.05 after 65, 80 and 95 days after sowing (Table 1).

It is worthy that hybrid differences in growth characters in this study may be due to the differences in genetic structure, and to the hybrid differences in glucose required for synthesis of different chemical constituents for different plant parts, in carbon equivalent and in partitioning of photoynthates among the plants (Ahmed, and Hassanein, 2000); also; to the widely differences between genotypes for mineral element concentrations (Clark, *et al* 1997and Abou EL-Seoud, 2010).

On the other hand, the inconconstant decline in stem + sheats dry weight / plant and blades area / plant after 80 days age could be attributed to the hybrid differences in migration of dry matter from vegetative organs (i.e. stems +sheats and blades) to ears and also to hybrid differences in photoynthate partitioning (Sundy, *et al* 1997; Zaki, *et al* 1999; ;Ahmed and Hassanein, 2000).

Generally, the hybrid differences in growth characters are in good agreement with the results obtained by Zaki *et al* (1999), Ahmed and Hassanein (2000), Kleinhez (2003), El–Koomy (2005), Sadek *et al* (2006a, b) and Mirdad (2010).

Hybrid Differences in Yield and its Components:

There were significant differences between the nine yellow maize hybrids under study S.C. 151, S.C. 155, S.C. 161, S.C. 162, S.C. 168, S.C. Pioneer 3062, S.C. Pioneer 3084, T.W. 351 and T.W. 352 in plant height, stem diameter, ear diameter, ear length, number of ears / plant, ears dry wt. / plant, number of rows / ear, number of kernels / row, RPP_{kr}, RPP_{bio}, RPP_{veg}, kernels yield / plant, straw yield / plant, migration coefficient, kernels yield/ fed., straw yield/fed. and harvest index except the difference in crop index was not significant (Table 2). Furthermore, data illustrated in the same table showed that S.C. 161 significantly surpassed other eight yellow maize hybrids under study in each of plant height, stem diameter, ear diameter, ear length, number of ears / plant, ears dry wt. / plant, number of rows / ear, number of kernels / row, RPP_{kr}, RPP_{bio}, kernels yield /plant, straw yield / plant, kernels yield / fed., straw yield / fed. and biological yield / fed., whereas, S.C. 151 produced the greatest migration coefficient, meanwhile, S.C. 155 had the highest significant value from harvest index, while T.W. 351 gave the highest value of RPP_{veg}, compared with other eight hybrids under study.

Hybrid differences in this study may be attributed to differences in genetic structure between the ten yellow maize hybrids also to the hybrid differences in growth characters (Table 1), and to the hybrid differences in photosynthetic partitioning that found in the following part of this study (Tables 3 and 4) ; that previously indicated by Zaki *et al* (1999), Ahmed and Hassanien (2000), and Sadek *et al* (2006a, b). Again, the widely differences between maize genotypes for mineral concentrations that found by Clark *et al* (1997) and Abou El Seoud and Wafaa (2010) can be attribute the hybrid differences in yield and its components. Furthermore, the significant superiority of S.C. 161 over the other eight yellow maize hybrids.

Table 1: Cultivar differences in growth characters of nine yellow maize hybrids (Average of 2008 and 2009 seasons).

Hybrids Plant age	S.C. 151	S.C. 155	S.C. 161	S.C. 162	S.C. 168	S.C.Pioneer 3062	S.C.Pioneer 3084	T.W. 351	T.W. 352	L.S.D.at 0.05 level
					Plant height "cm"					
65	169.25	205.54	217.09	211.17	197.85	161.7	159.2	163.7	175.8	5.12
80	280.5	301.7	305.84	302.67	275.85	268.9	266	273	291.4	1.68
95	272	290.8	298.6	292.78	273.4	267.4	264	270	272.4	4.27
					Number of active leaves / plant					
65	14.45	16	16.8	16.7	15.7	13.8	13.6	14	14.75	0.07
80	15.4	16.75	17.2	17	16.3	14.2	14.2	15	16	0.12
95	14	15.6	16.3	16	15	13	13	13.2	14.5	0.09
					Number of ears / plant					
65	-	-	-	-	-	-	-	-	-	-
80	1.2	1.33	1.5	1.45	1.2	1.1	1.1	1.25	1.33	0.05
95	1.1	1.33	1.5	1.45	1.1	1	1	1.17	1.17	0.04
					Stem + sheats dry weight "g / plant"					
65	68.5	72.44	74.64	73.8	70.5	80.95	76.4	81.18	84.75	0.73
80	78.6	84.27	91.23	88.37	80.75	102.49	97.62	110.22	114.1	1.26
95	68.28	71.8	76.31	73.91	70.85	82.69	79.86	88.6	92.12	2.08
					Blades dry weight "g / plant"					
65	39.22	42.93	44.31	43.35	41.43	45.02	44.74	45.74	46.91	0.71
80	45.8	47.58	49.52	48.64	46.17	51.4	50.01	52.29	53.33	0.82
95	41.63	42.9	44.51	43.78	42.28	48.55	47.66	49.52	49.98	0.56
					Ears dry weight "g / plant"					
65	-	-	-	-	-	-	-	-	-	-
80	54.64	57.8	60.85	58.67	55	53.21	53	56.27	57.94	1.59
95	87.24	97.67	105.12	101.79	90.88	87	86.96	93.08	98.7	2.68
					Flag leaf blade area "cm2/plant"					
65	113.11	125.64	142.9	137.54	103.72	101	97.1	107.22	135.77	3.54
80	152.43	160.45	186.19	180.3	135.67	126.5	121.6	138.84	169.3	3.91
95	139.72	148.73	167.51	162.73	110.5	104.3	102.54	115.6	151.34	3.07
					4th leaf blade area "cm2/plant"					
65	465.33	497.74	526.14	515.64	425.72	422.47	417.3	444.5	508.37	8.57
80	498.2	513.8	560.82	542.2	447.22	439	435	475	538.4	17.7
95	462.43	477.63	520.47	513.08	419.7	413	411	440.3	504.44	4.48
					Flag leaf angle					
65	41.7	37.4	31	35	39	45	47.1	43.2	40.6	2.34
80	47	43.7	40	42	45.4	51	52	48	46	1.65
95	56	51.5	48	50	53	61	66	57	54.7	1.71
					4th leaf angle					
65	46.5	45	39	41	45.8	52	57	57.1	46.2	1.36
80	51	46.2	42	45	48.5	56.5	59.5	61	50	2.28
95	63	57	52	54.4	60	63.5	64	65	62.4	1.74
					Blades area "cm2/plant"					
65	4866	5194.68	5320	5277.4	5073.26	4773	4688	4606.53	4971.3	31.55
80	5001.29	5500.39	5664.28	5568.92	5443.71	4850	4730.14	4699	5361	29.19
95	4600.7	4975.47	5105.9	5065.14	4737	4571	4491	4400	4674.3	46.3
					Leaf area index					
65	3.24	3.46	3.55	3.52	3.38	3.18	3.13	3.07	3.31	0.02
80	3.33	3.67	3.78	3.71	3.63	3.23	3.15	3.13	3.57	0.05
95	3.07	3.32	3.4	3.38	3.16	3.05	2.99	2.93	2.72	0.02

under this study in ears dry weight / plant, RPP_{kr}, RPP_{bio}, kernels yield for plant and / or fed. may be due to the high yielding cultivar had a more vigorous system for generating reducing potentials during plant growth than did the less productive cultivar and the higher yielding cultivar has a higher photosynthetic electron transport chain potential, which is a genetically character more than lower yielding cultivar (Ahmed and Hassanein, 2000). 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 harvest by S.C. 161 (Table 2). The important of number of kernels is suggested by the increase in number of kernels per unit area of land that have accompanied that recent increase in yield shown by new cultivars (Pendelton, W.J., 1968). On the other hand, the small angel between stem and flag leaf and 4^{th} leaf and greatest flag and 4^{th} leaves blades areas of S.C. 161 may be due to a cause of highest kernels yield, where, the effect of small angle flag leaf and 4^{th} leaf might be attributed to leaf orientation and its effect on light interception and penetration in the plant canopy (Ahmed and Hassanein, 2000). Also, Pucridge (1971) reported that changes in LAI caused a variation in CO_2 uptake and the differences in kernels yield from anthesis onwards were correlated with LAI and CO_2 uptake, thus, the hybrids differences in LAI in Table (1) may be a cause hybrid differences in kernels yield.

Table 2: Cultivar differences in yield and its components of nine yellow maize hybrids (Average of 2008 and 2009 seasons).

Hybrids Yield and its components	S.C. 151	S.C. 155	S.C. 161	S.C. 162	S.C. 168	S.C. Pioneer 3062	S.C. Pioneer 3084	T.W. 351	T.W. 352	L.S.D.at 0.05 level
Plant height "cm"	271.58	286.3	293	290	258	255.7	254.2	269.8	270.29	2.25
Stem diameter "cm"	2.63	2.84	2.93	2.87	2.75	2.55	2.49	2.59	2.69	0.04
Ear diameter "cm"	4.85	5.41	5.56	5.5	4.83	4.52	4.5	4.73	4.99	0.03
Ear length "cm"	21.75	22.25	24.92	23.5	21.75	21.2	21	21.5	22.6	1.29
No. of ears/plant	1.3	1.5	1.67	1.6	1.1	1	1	1.2	1.4	0.11
Ears dry wt. "g/plant"	240.98	243.54	255.35	250.14	235.1	237.7	233	237.8	239.4	6.45
No. of rows/ear	15	15.4	16	15.8	14.4	13.8	13.7	14	15.2	0.15
No. of kernels/row	47.2	49	50.8	49.5	46.75	45	42.35	44.5	48.7	1.11
RPPkr "g/LAI"	81.45	81.48	89.49	85.34	79.99	78.03	78.51	84.78	83.91	2.48
RPPbio "g/LAI"	169.73	170.88	184.27	177.31	166.9	173.06	174.7	181.6	175.98	1.61
RPPveg."g/plant"	88.28	89.4	94.78	91.97	86.91	95.03	96.19	96.82	92.07	0.52
Kernels yield ."g/plant"	169.63	185.19	194.25	188.96	171.95	165.4	166.3	158.03	164.33	11.44
Straw yield ."g/plant"	232.5	262.9	290.28	276.51	245.5	248	245	242.4	260	9.54
Migration coefficient	0.599	0.544	0.527	0.537	0.563	0.575	0.566	0.594	0.564	0.002
Kernels yield "ton/fed"	3.11	3.436	3.602	3.53	3.293	3.226	3.103	3.2	3.228	0.049
Straw yield "ton/fed"	3.91	4.13	4.38	4.29	3.98	3.98	3.83	3.88	4.12	0.06
Biological yield "ton/fed"	7.02	7.566	7.982	7.82	7.273	7.206	6.933	7.08	7.348	0.151
Crop index	0.443	0.454	0.451	0.451	0.453	0.448	0.448	0.452	0.439	n.s
Harvest index	0.795	0.832	0.832	0.822	0.827	0.811	0.811	0.825	0.783	0.003

Hybrid differences in yield and its components in this study are in harmony with the results obtained by Zaki *et al* (1999), Ahmed and Hassanien (2000), Kleinhez (2003), El-Koomy (2005), Sadek *et al* (2006a, b) and Mirdad (2010).

Photosynthates Partitioning:

The partitioning coefficient would be determined by the capacity of the photosynthetic sink related by the ear. When plants reached the final weeks of the filling period (soft dough stage to ripe stage), the coefficient of partitioning may increase evidence for these is shown by very rapid decline in the canopy in the final weeks and the possible scavenging of nutrients from vegetative plant parts.

There were significant differences between maize hybrids in crop growth rate (Table 3) and ears dry weight / plant at different stages (Table 1). Moreover, S.C. 161 yellow hybrid significantly exceeded the other eight yellow hybrids in crop growth rate (Table 3) and ears dry weight / plant (Table 1). Again, crop growth rate tended to increase with advancing age until 80 days and then declined with advancing age from 80 to 95 days after sowing (Table 3). On the contrary ears dry weight / plant tended to increase lineary from 65 days after planting (Table 1).

It is noteworthy mention that CGR values of vegetative organs reflects, the total amount of photosynthate partitioned into the yield components. The partitioning coefficient can not be approximated from a simple ratio of the slope of crop growth rate since more photosynthate 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 (Penning De vries, *et al* 1974; Mc. Graw, 1977; Hanson, *et al* 1960; Ahmed and Hassanein, 2000).

To estimate the amout 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 nine yellow maize hybrids in carbohydrate and protein in vegetative organs, kernels and straw, as well as, in oil percentage in kernels (Table 3). Moreover, S.C. 161 significantly outweighed the other eight yellow maize hybrids (S.C. 151, S.C. 155, S.C. 162, S.C. 168, S.C. Pioneer 3062, S.C. Pioneer 3084, T.W. 351 and T.W. 352) in carbohydrate and protein percentages per vegetative organs, kernels and straw, also in oil percentage per kernels (Table 3).

Data reported in Table (3) observed clearly that glucose required for synthesis of the chemical compounds by the various maize hybrids components. Differences among maize hybrids in glucose required for synthesis of carbohydrate in vegetative organs ; kernels and straw and in glucose required for synthesis of oil per kernels. In addition, S.C. 161 required more glucose for synthesis of carbohydrate and protein by vegetative organs, kernels and straw and required more glucose for synthesis of oil by kernels.

Regarding carbon equivalent, according to Hanson *et al* (1960) carbon equivalent is defined as the gram atoms of sugar carbon required to produce product including both grams atom of work carbon lost in the synthesis and gram atoms of carbon stored in the product. Data in Table (3) revealed significant differences

Table 3: Differences in chemical constituents, glucose required for synthesis and carbon equivalent for vegetative parts, kernels and straw of nine yellow maize hybrids (Average of 2008 and 2009 seasons).

	S.C. 151	S.C. 155	S.C. 161	S.C. 162	S.C. 168	S.C. Pioneer 3062	S.C. Pioneer 3084	T.W. 351	T.W. 352	L.S.D.at 0.05 level
Carbohydrate, protein and oil percent										
Vegetative organs:-										
Carbohydrate	71.47	73.28	78.89	75.63	72.79	70.67	70.38	70.2	71.7	1.69
Protein	10.43	11.51	12.08	11.84	11.27	10.37	10.16	10.14	10.67	0.16
Kernels :-										
Carbohydrate	74.89	78.17	81.8	80.15	77.49	74.42	73.5	71.92	76.03	1.52
Protein	10.28	10.76	12.71	12.29	10.22	10.16	10.19	9.83	10.37	0.28
Oil	2.3	2.71	2.88	2.73	2.68	2.23	2.17	2.11	2.6	0.13
Straw :-										
Carbohydrate	72.3	74.56	77.49	75.34	73.5	71.92	71.69	71.58	72.89	1.14
Protein	9.97	10.37	11.24	11.06	10.28	9.83	9.72	9.65	10.09	0.12
Glucose required for carbohydrate, protein and oil synthesis										
Vegetative organs:-										
Carbohydrate	0.838	0.859	0.924	0.887	0.853	0.828	0.825	0.823	0.841	0.017
Protein	0.168	0.186	0.194	0.191	0.182	0.167	0.164	0.164	0.172	0.002
Kernels :-										
Carbohydrate	0.878	0.916	0.959	0.94	0.908	0.872	0.862	0.843	0.891	0.011
Protein	0.166	0.174	0.205	0.198	0.165	0.164	0.164	0.159	0.167	0.005
Oil	0.066	0.077	0.082	0.078	0.076	0.064	0.062	0.06	0.076	0.003
Straw :-										
Carbohydrate	0.848	0.862	0.908	0.883	0.862	0.843	0.84	0.839	0.855	0.009
Protein	0.161	0.167	0.181	0.178	0.166	0.159	0.175	0.156	0.163	0.001
Carbon equivalent										
Vegetative organs:-										
Carbohydrate	28.59	29.31	31.25	30.26	29.12	28.27	28.15	28.08	28.68	0.68
Protein	8.2	9.05	9.49	9.31	8.87	8.16	7.99	7.97	8.39	0.15
Kernels :-										
Carbohydrate	29.96	31.27	32.72	32.06	31	29.77	29.4	28.77	30.41	0.43
Protein	8.08	8.46	9.99	9.66	8.04	7.99	8.01	7.73	8.16	0.31
Oil	2.16	2.39	2.45	2.43	2.38	2.15	2.15	2.14	2.28	0.002
Straw :-										
Carbohydrate	28.92	29.82	31	30.11	29.4	28.77	28.68	28.63	29.16	0.55
Protein	7.84	8.16	8.83	8.69	8.08	7.73	7.64	7.58	7.94	0.11
Crop growth rate (mg/cm2/day)										
a. 65 – 80 days after sowing	5.14	5.89	6.93	6.56	6.68	5.02	4.84	4.64	5.35	0.08
a. 80 – 90 days after sowing	4.72	5.23	5.87	5.38	5.16	4.79	4.31	4.15	4.89	0.14

among yellow maize hybrids in carbon equivalent for each carbohydrate and protein of vegetative organs, kernels and straw, as well as, oil in kernels. Also, S.C. 161 characterized with a high carbon equivalent for each of carbohydrate and protein in vegetative organs ; kernels and straw and for oil in kernels.

Data illustrated in Table (4) indicate that there were significant differences among the nine yellow maize hybrids under this study in yield energy per plant and per fedden, where, yellow maize hybrids significantly differed in energy yield per each of carbohydrate, protein and oil. Furthermore, S.C. 161 significantly outweighed other eight yellow maize hybrids under study in energy yield of carbohydrate and protein in kernels and straw and energy yield of oil in kernels per plant and / pr per fedden. Thus, the yellow maize hybrid S.C. 161 had the greatest significant values from total energy yield of kernels and / or straw per plant and fedden compared with other eight cultivars under study. Again, S.C. 162 had the highest significant value from energy coefficient for harvest index and insignificantly surpassed hybrids 151, 155, 161, S.C. 168, S.C. Pioneer 3062, S.C. Pioneer 2084, T.W. 351 and T.W. 352 in energy coefficient for crop index.

Again, as mentioned before, harvest yellow maize yield can be increased by growing single crosses S.C 161, S.C. 162, S.C. 155, S.C. 168 Pioneer 3062 and three-way cross T.W. 352 that characterized by highest efficiency partitioned photosynthates towards economic yield.

Correlation Studies:

Data recorded in Table (5) shows that correlation coefficient estimates between kernels yield / plant and other studies characters. Highly significant and positive correlation estimates were detected between plant

Table 4: Hybrid differences in energy yield per plant and / or per fed. at harvest of yellow maize hybrids (combined analysis of 2008 and 2009 seasons).

Hybrids Parameter	S.C. 151	S.C. 155	S.C. 161	S.C. 162	S.C. 168	S.C. Pioneer 3062	S.C. Pioneer 3084	T.W. 351	T.W. 352	L.S.D.at 0.05 level
Yield energy / plant at harvest K cals										
Kernels :-										
Carbohydrate	501.79	571.81	627.64	598.23	526.31	486.21	482.81	448.94	493.51	12.68
Protein	79.69	91.06	112.83	106.13	80.15	76.8	77.44	70.99	77.88	3.47
Oil	36.67	47.18	52.59	48.49	43.32	34.67	33.92	31.34	40.16	3.15
Total	618.15	710.05	793.06	752.85	649.78	597.68	594.17	551.27	611.55	15.49
Straw :-										
Carbohydrate	663.99	774.27	888.5	822.87	712.75	704.53	693.78	685.36	748.58	13.62
Protein	105.93	124.59	149.51	139.76	115.33	111.41	108.83	106.9	119.88	7.44
Total	809.32	898.86	1038.01	962.63	828.08	815.94	802.61	792.26	868.47	9.36
Yield energy / fed. at harvest 106 K cals										
Kernels :-										
Carbohydrate	9.2	10.61	11.64	11.18	10.08	9.48	9.01	9.09	9.69	0.14
Protein	1.46	1.69	2.09	1.98	1.54	1.5	1.45	1.44	1.53	0.08
Oil	0.67	0.88	0.98	0.91	0.83	0.68	0.63	0.63	0.79	0.05
Total	11.33	13.18	14.71	14.06	12.45	11.66	11.09	11.16	12.01	0.15
Straw :-										
Carbohydrate	11.17	12.16	13.41	12.77	11.55	11.31	10.85	10.97	11.86	0.25
Protein	1.78	1.96	2.25	2.17	1.87	1.79	1.7	1.71	1.9	0.06
Total	12.95	14.12	15.66	14.94	13.42	13.1	12.55	12.68	13.76	0.2
Energy coefficient										
Energy coefficient for crop index	0.468	0.483	0.484	0.485	0.481	0.471	0.469	0.468	0.466	n.s
Energy coefficient for harvest index	0.875	0.933	0.939	0.941	0.928	0.89	0.884	0.88	0.873	0.02

Table 5: Simple correlation coefficient between kernels yield and some yield components and growth characters of nine yellow maize hybrids (Average of 2008 and 2009 seasons).

		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}	X_{15}
Kernels yield/plant		-0.167	0.878**	0.939**	0.898**	0.838**	0.758**	0.903**	0.602**	0.664**	0.772**	-0.399	-0.226	0.805**	0.915**	0.795**
Plant height	X_1		-0.251	-0.263	-0.279	-0.399	0.774**	0.663**	0.649**	0.340	0.417	-0.294	-0.286	0.719**	0.725**	0.667**
Ear diameter	X_2			-0.238	-0.169	0.670**	0.342	0.698**	0.714**	0.665**	0.394	-0.314	-0.477*	0.654**	0.576*	0.315
Ear length	X_3				0.854**	-0.060	0.54*	0.943**	0.507*	0.742**	0.229	-0.742**	-0.794**	0.717**	0.811**	0.945**
No. of ears / plant	X_4					0.904**	0.789**	0.515*	0.897**	0.550*	0.783**	0.374	0.784**	0.815**	0.792**	0.894**
Ears dry wt. / plant	X_5						0.968**	0.794**	0.644**	0.66**	0.589*	-0.339	-0.314	0.719**	0.822**	0.743**
No. of rows / ear	X_6							0.622**	0.547*	0.599**	0.614**	-0.283	-0.314	0.813**	0.732**	0.578*
No. of kernels / row	X_7								0.467	0.691**	0.690**	-0.288	-0.419	0.820**	0.832**	0.725**
RPP_{kr}	X_8									0.764**	0.635**	-0.620**	-0.606**	0.585*	0.621**	0.736**
Flag leaf blade area	X_9										0.329	-0.121	-0.142	0.561*	0.595**	0.408
4th leaf blade area	X_{10}											-0.374	-0.229	0.724**	0.768**	0.655**
Flag leaf angle	X_{11}												0.551*	-0.411	-0.289	-0.167
4th leaf angle	X_{12}													0.811**	-0.748**	-0.472*
Blades area / plant	X_{13}														1.00**	0.885**
LAI	X_{14}															0.442
Migration coefficient	X_{15}															

kernels yield and each of ear diameter, ear length, number of ears / plant, ears dry weight / plant, number of rows / ear, number of kernels / row, RPP_{Kr}, flag leaf blade area, 4th leaf blade area, blades area / plant, LAI and migration coefficient, between plant height and number of rows / ear, number of kernels / row, RPP_{Kr}, blades area / plant, LAI and migration coefficient, between ear diameter and each one of ears dry weight / plant, number of kernels / row, RPP_{Kr}, flag leaf blade area, blades area / plant and LAI, between ear length and number of ears / plant, number of kernels / row, flag leaf blade area, blades area / plant, LAI and migration coefficient. Moreover, the relationship between number of ears / plant and ears dry weight / plant, number of rows / ear, number of kernels / row, RPP_{Kr}, 4th leaf blade area, blades area / plant, LAI and migration coefficient, between ears dry weight / plant and number of rows / ear, number of kernels / row, RPP_{Kr}, flag leaf blade area, 4th leaf blade area, blades area / plant, LAI and migration coefficient, between number of rows / ear and number of kernels / row and flag leaf blade area, 4th leaf blade area, blades area / plant, LAI and migration coefficient were positive and high significant (Table 5). Also, the association between RPP_{Kr} and flag leaf blade area, 4th leaf blade area, LAI and migration coefficient, between 4th leaf blade area and each blades area / plant, LAI and migration coefficient and between blades area / plant and LAI and migration coefficient were positive and highly significant. On the contrary, there were negative and highly relationships between ear length and RPP_{Kr} also and each flag leaf angle and 4th leaf angle and between 4th leaf angle and blades area and LAI (Table 5).

Positive and significant association was found between ear diameter and LAI, between ear length and number of rows / ear, between number of ears / plant and number of kernels / row and flag leaf area, between ears dry weight / plant and 4th leaf blade area, between number of rows / ear and RPP_{Kr} and migration coefficient and between blades area / pant and RPP_{Kr} and flag leaf blade area (Table 5).

On the other hand, the simple correlation between migration coefficient and flag leaf blade area, LAI and ear diameter, between 4th leaf blade area and flag leaf blade area, plant height, ear diameter, ear length, between plant height and flag leaf blade area, between ear diameter and number of rows ear, between number of ear / plant and flag leaf angle and between number of kernels / row and RPP_{Kr} was positive and insignificant, meanwhile, the relationships between flag leaf angle and each kernels yield / plant, ear diameter, plant height, number of ears / row, ears dry weight / plant, number of rows / ear, RPP_{Kr}, and flag leaf blade area, between 4th leaf angle and each one of kernels yield / plant, plant height, number of ears / plant, ears dry weight / plant, number of rows / ear, RPP_{Kr} and flag leaf blade area, between plant height and kernels yield / plant, between ear length and ears dry weight / plant, plant height and ear diameter, between ear diameter and number of ears/ plant, between plant height and number of ears / plant and ears dry weight / plant and between 4th leaf blade area and blades area / plant, LAI and migration coefficient were negative and insignificant (Table 5).

It is noteworthy to mention that our results are in harmony with those obtained by Zaki *et al* (1999) and Ahmed and Hassanein (2000), in addition, the positive correlation between grain yield and LAI might be due to that changes in LAI caused a variation in CO_2 uptake and the differences in grain yield from anthesis onwards were correlated with LAI and CO_2 uptake (Ahmed, 1989). Furthermore, Thorne *et al* (1969), showed that LAI equal six, about 85% of the incident photosynthetically active radiation was intercepted. When LAI was increased to 10 interception was 95%. Thus kernels yield increases almost linearly with increase in LAI at anthesis.

Path Coefficient Analysis:

Table (6) reveals that partitioning of average simple correlation coefficient between kernels yield/plant and some yield components, i.e. ear diameter, ear length number of ears /plant, ears dry weight/plant, number of rows/ear, number of kernels/row, RPP_{Kr} and migration coefficient and some growth characters, i.e. flag leaf area, 4th leaf area, blades area and LAI as average of nine yellow maize hybrids under study. 4thleaf area proved to have direct effect on kernels yield/plant compared with number of rows/ear, migration coefficient, RPP_{kr}, ear diameter, ear length and LAI. On the other hand ears dry weight/plant had a high negative direct effect on kernels yield compared with blades area/plant, flag leaf area, number of kernels/row and number of ears/plant since the average means of the direct effect were 79.353, 53.531, 8.75, 5.705, 3.150, 2.027, 0.669, -64.694, -2.685, -13.414, -16.587, -41.548, respectively. Again, as mentioned before (Table 5), total correlation coefficient was most pronounced in the ear length (r = 0.939) than in LAI (r = 0.915), number of Kernels / row (r = 0.903), number of ears/plant (r = 0.898), ear diameter (r = 0.878), ears dry weight (r – 0.838), blades area /plant (r = 0.805) migration coefficient (r = 0.795), 4th leaf area (r= 0.772), number of rows/ear (r = 0.758), flag leaf area (r= 0.664) and RPP_{kr} (r= 0.602).

Table (7) shows that the direct effect of 4th leaf area was 9.15% of the variation being higher than that of ears dry weight / plant (6.08%), number of rows /ear (4.16%), number of ears/plant (2.50%), number of Kernels / row (0.40%), flag leaf area (0.26%), migration coefficient (0.11%) RPP_{Kr} (0.05%), ear diameter (0.014%), blades area / plant (0.01%), ear length (0.006%) and LAI (0.001%). The joint effect of ear diameter with ear length, number of ears/plant, ears dry wt. /plant, No. of rows /ear, No. of Kernels / row, RPP_{Kr}, flag leaf area, 4th leaf area, blades area / plant, LAI and migration coefficient 0.004, 0.06, 0.79, 0.17, 0.54, 0.04, 0.08, 0.29, 0.02, 0.004, and 0.03%, respectively . The joint effect of ear length with No. of ears / plant, ears dry wt. /plant, No. of rows /ear, No. of kernels /row, RPP_{Kr}, flag leaf area, 4thleaf area, blades area, LAI and migration coefficient formed 0.60, 0.023, 0.17, 0.092, 0.02, 0.06, 0.11, 0.01, 0.003, and 0.05% of the variation, respectively. Moreover, the joint effect of No. of ears /plant with ears dry wt. /plant, No. of rows / ear, No. of kernels /row, RPP_{Kr}, flag leaf area, 4th leaf area, blades area, LAI and migration coefficient amounted to 7.06, 5.10, 1.03, 0.62, 0.89, 7.79, 0.26, 0.11, and 0.94% of the variation, respectively . In addition, the joint effect of ears dry wt. / plant with No. of rows / ear, No. of kernels /row, RPP_{Kr}, flag leaf area, 4thleaf area, blades area, LAI, and migration coefficient were 11.05, 2.48, 2.14, 1.67, 9.51, 0.36, 0.10 and 1.22% of the variation, respectively . Regarding the joint effect of No. of rows /ear with No. of kernels / row, RPP_{KR}, flag leaf area, 4th leaf area, blades area, LAI and migration coefficient they amounted 3.06, 0.49, 1.25, 7.58, 0.47, 0.08, and 0.79% of the variation, meanwhile the joint effect of No. of Kernels / row with RPP_{Kr}, flag leaf area, 4th leaf area, blades area / plant, LAI and migration coefficient were 0.12, 0.45, 2.64, 0.11, 0.03 and 0.31 of the variation, respectively.

Table 6: Path coefficient analysis of simple correlation coefficient for nine yellow maize hybrids.

Source	Correlation	Source	Correlation	Source	Correlation
Kernels yield via. ear diameter		Kernels yield via. No. of ears/plant		Kernels yield via. No. of rows/ear	
Direct effect	3.15	Direct effect	-41.548	Direct effect	53.531
Indirect via. ear length	-0.482	Indirect via. ear diameter	-0.532	Indirect via. ear diameter	1.077
Indirect via. No. of ears/plant	7.022	Indirect via. ear length	1.731	Indirect via. ear length	1.095
Indirect via. ears dry wt. /plant	-43.345	Indirect via. ears dry wt. /plant	-58.483	Indirect via. No. of ears/plant	-32.781
Indirect via. No. of rows/ear	18.308	Indirect via. No. of rows/ear	42.236	Indirect via. ears dry wt. /plant	-59.624
Indirect via. No. of kernels/row	-11.578	Indirect via. No. of kernels/row	-8.542	Indirect via. No. of kernels/row	-10.317
Indirect via. RPPkr	4.073	Indirect via. RPPkr	5.116	Indirect via. RPPkr	3.219
Indirect via. flag leaf area	-8.92	Indirect via. flag leaf area	-7.378	Indirect via. flag leaf area	-8.035
Indirect via. 4th leaf area	31.265	Indirect via. 4th leaf area	62.133	Indirect via. 4th leaf area	49.237
Indirect via. blades area/plant	-1.756	Indirect via. blades area/plant	-2.188	Indirect via. blades area/plant	-2.183
Indirect via. LAI	0.385	Indirect via. LAI	0.53	Indirect via. LAI	0.49
Indirect via. migration coefficient	2.756	Indirect via. migration coefficient	7.823	Indirect via. migration coefficient	5.058
Total correlation	0.878	Total correlation	0.898	Total correlation	0.758
Kernels yield via. ear length		Kernels yield via. ears dry wt. /plant		Kernels yield via. No. of kernels/row	
Direct effect	2.027	Direct effect	-64.694	Direct effect	-16.587
Indirect via. ear diameter	-0.75	Indirect via. ear diameter	2.111	Indirect via. ear diameter	2.199
Indirect via. No. of ears/plant	-35.482	Indirect via. ear length	-0.122	Indirect via. ear length	1.911
Indirect via. ears dry wt. /plant	3.882	Indirect via. No. of ears/plant	-31.559	Indirect via. No. of ears/plant	-21.397
Indirect via. No. of rows/ear	28.907	Indirect via. No. of rows/ear	51.818	Indirect via. ears dry wt. /plant	-51.367
Indirect via. No. of kernels/row	-15.642	Indirect via. No. of kernels/row	-13.107	Indirect via. No. of rows/ear	33.296
Indirect via. RPPkr	2.892	Indirect via. RPPkr	3.673	Indirect via. RPPkr	2.664
Indirect via. flag leaf area	-9.953	Indirect via. flag leaf area	-8.853	Indirect via. flag leaf area	-9.269
Indirect via. 4th leaf area	18.172	Indirect via. 4th leaf area	56.541	Indirect via. 4th leaf area	54.754
Indirect via. blades area/plant	-1.925	Indirect via. blades area/plant	-1.931	Indirect via. blades area/plant	-2.202
Indirect via. LAI	0.543	Indirect via. LAI	0.55	Indirect via. LAI	0.557
Indirect via. migration coefficient	8.269	Indirect via. migration coefficient	6.501	Indirect via. migration coefficient	6.344
Total correlation	0.939	Total correlation	0.838	Total correlation	0.903
Kernels yield via. RPPkr		Kernels yield via. 4th leaf area		Kernels yield via. LAI	
Direct effect	5.704	Direct effect	79.353	Direct effect	0.669
Indirect via. ear diameter	2.249	Indirect via. ear diameter	1.241	Indirect via. ear diameter	1.814
Indirect via. ear length	1.028	Indirect via. ear length	0.464	Indirect via. ear length	1.644
Indirect via. No. of ears/plant	-36.269	Indirect via. No. of ears/plant	-34.532	Indirect via. No. of ears/plant	-32.806
Indirect via. ears dry wt. /plant	-40.663	Indirect via. ears dry wt. /plant	-38.105	Indirect via. ears dry wt. /plant	-53.178
Indirect via. No. of rows/ear	29.821	Indirect via. No. of rows/ear	8.78	Indirect via. No. of rows/ear	39.185
Indirect via. No. of kernels/row	-6.746	Indirect via. No. of kernels/row	-19.445	Indirect via. No. of kernels/row	-13.8
Indirect via. flag leaf area	-10.248	Indirect via. RPPkr	3.623	Indirect via. RPPkr	3.242
Indirect via. 4th leaf area	50.389	Indirect via. flag leaf area	-4.913	Indirect via. flag leaf area	-7.881
Indirect via. blades area/plant	-1.518	Indirect via. blades area/plant	-1.944	Indirect via. 4th leaf area	60.843
Indirect via. LAI	0.415	Indirect via. LAI	0.514	Indirect via. blades area/plant	-2.685
Indirect via. migration coefficient	6.44	Indirect via. migration coefficient	5.731	Indirect via. migration coefficient	3.868
Total correlation	0.602	Total correlation	0.772	Total correlation	0.915
Kernels yield via. flag leaf area		Kernels yield via. blades area/plant		Kernels yield via. migration	
Direct effect	-13.414	Direct effect	-2.685	Direct effect	8.75
Indirect via. ear diameter	5.775	Indirect via. ear diameter	2.06	Indirect via. ear diameter	0.992
Indirect via. ear length	1.904	Indirect via. ear length	1.453	Indirect via. ear length	1.916
Indirect via. No. of ears/plant	-22.851	Indirect via. No. of ears/plant	-32.861	Indirect via. No. of ears/plant	-37.144
Indirect via. ears dry wt. /plant	-24.698	Indirect via. ears dry wt. /plant	-46.515	Indirect via. ears dry wt. /plant	-43.152
Indirect via. No. of rows/ear	32.065	Indirect via. No. of rows/ear	43.52	Indirect via. No. of rows/ear	30.941
Indirect via. No. of kernels/row	-11.462	Indirect via. No. of kernels/row	-12.601	Indirect via. No. of kernels/row	-11.026
Indirect via. RPPkr	4.558	Indirect via. RPPkr	3.337	Indirect via. RPPkr	4.198
Indirect via. 4th leaf area	26.207	Indirect via. flag leaf area	-7.525	Indirect via. flag leaf area	-4.573
Indirect via. blades area/plant	-1.506	Indirect via. 4th leaf area	57.252	Indirect via. 4th leaf area	51.976
Indirect via. LAI	0.398	Indirect via. LAI	-0.5	Indirect via. blades area/plant	-2.376
Indirect via. migration coefficient	3.67	Indirect via. migration coefficient	-4.13	Indirect via. LAI	0.296
Total correlation	0.664	Total correlation	0.805	Total correlation	0.795

It is worthy to mention that the joint effect of RPP_{Kr} with flag leaf area, 4^{th}leaf area, blades area / plant, LAI and migration coefficient amounted to 0.17, 0.83, 0.03, 0.01, and 0.11, whereas, the joint effect of flag leaf area with 4^{th}leaf area, blades area, LAI and migration coefficient were 1.02, 0.06, 0.02, and 0.14% of the variation, while ; the joint effect of 4^{th}leaf area with blades area / plant, LAI and migration coefficient formed 0.45, 0.12, and 1.32% of the variation .

Again, the joint effect of blades area / plant with LAI and migration coefficient were 0.002 and 0.01%, while the joint effect of LAI with migration coefficient was 0.01% of the variation .

As mentioned before, 4^{th}leaf area, ears dry wt. / plant, No. of rows /ear and No. of ears /plant were the most effective in contributing to kernels yield since the direct effect amounted to 9.15, 6.08, 4.16 and 2.50% of the variation, respectively, meanwhile, the joint effect of 4^{th}leaf area with No. of ears / plant, ears dry wt. / plant, No. of rows / ear and No. of kernels / row formed 7.79, 9.51, 7.58 and 2.64 % of the variation, the joint effect of ears dry wt. with No. of rows / ear No. of Kernels / row and RPP_{Kr} amounted to 11.05, 2.48, and 2.14 % of the variation, respectively .

Here, it is worthy to mention that those parameters, i.e. 4^{th}leaf area ears dry wt. / plant, No. of rows /ear and No. of ears / plant could contribute much of yellow maize Kernels yield since R^2 was 99.85 of the total variation.

Table 7: Direct and joint effects of some yield components and growth characters in nine yellow maize hybrids.

Characters	Coefficient of determination	Percentage contribution %	Characters	Coefficient of determination	Percentage contribution %	Characters	Coefficient of determination	Percentage contribution %
Ear diameter	9.923	0.014	Ear length X No. of kernels/row	-63.41	0.092	No. of rows/ear X Flag leaf area	-860.24	1.25
Ear length	4.109	0.006	Ear length X RPP_{kr}	11.72	0.02	No. of rows/ear X 4^{th} leaf area	5216.35	7.58
No. of ears/plant	1726.24	2.50	Ear length X Flag leaf area	-40.35	0.06	No. of rows/ear X Blades area/plant	-323.71	0.47
Ears dry wt./plant	4185.31	6.08	Ear length X 4^{th} leaf area	73.67	0.11	No. of rows/ear X LAI	52.43	0.08
No. of rows/ear	2865.57	4.16	Ear length X Blades area/plant	-7.805	0.01	No. of rows/ear X Migration coefficient	541.47	0.79
No. of kernels/row	275.1	0.40	Ear length X LAI	2.20	0.003	No. of kernels/row X RPP_{kr}	-88.37	0.12
RPP_{kr}	32.536	0.05	Ear length X Migration coefficient	33.52	0.05	No. of kernels/row X Flag leaf area	307.49	0.45
Flag leaf area	179.94	0.26	No. of ears/plant X Ears dry wt./plant	4859.73	7.06	No. of kernels/row X 4^{th} leaf area	-1816.39	2.64
4^{th} leaf area	6296.9	9.15	No. of ears/plant X No. of rows/ear	-3509.64	5.10	No. of kernels/row X Blades area/plant	73.04	0.11
Blades area/plant	7.209	0.01	No. of ears/plant X No. of kernels/row	709.83	1.03	No. of kernels/row X LAI	-18.46	0.03
LAI	0.448	0.001	No. of ears/plant X RPP_{kr}	425.16	0.62	No. of kernels/row X Migration coefficient	-210.45	0.31
Migration coefficient	76.56	0.11	No. of ears/plant X Flag leaf area	613.06	0.89	RPP_{kr} X Flag leaf area	-116.91	0.17
Ear diameter X Ear length	-30.039	0.004	No. of ears/plant X 4^{th} leaf area	-5363.04	7.79	RPP_{kr} X 4^{th} leaf area	574.84	0.83
Ear diameter X No. of ears/plant	44.24	0.06	No. of ears/plant X Blades area/plant	181.84	0.26	RPP_{kr} X Blades area/plant	-17.92	0.03
Ear diameter X Ears dry wt./plant	-573.07	0.79	No. of ears/plant X LAI	-74.03	0.11	RPP_{kr} X LAI	4.74	0.01
Ear diameter X No. of rows/ear	115.34	0.17	No. of ears/plant X Migration coefficient	-650.02	0.94	RPP_{kr} X Migration coefficient	73.47	0.11
Ear diameter X No. of kernels/row	-372.94	0.54	Ears dry wt./plant X No. of rows/ear	-7604.63	11.05	Flag leaf area X 4^{th} leaf area	-700.40	1.02
Ear diameter X RPP_{kr}	25.66	0.04	Ears dry wt./plant X No. of kernels/row	1704.05	2.48	Flag leaf area X Blades area/plant	40.41	0.06
Ear diameter X Flag leaf area	-56.20	0.08	Ears dry wt./plant X RPP_{kr}	-1475.29	2.14	Flag leaf area X LAI	-10.68	0.02
Ear diameter X 4^{th} leaf area	196.97	0.29	Ears dry wt./plant X Flag leaf area	1145.50	1.67	Flag leaf area X Migration coefficient	-95.78	0.14
Ear diameter	-11.06	0.02	Ears dry wt./plant X 4^{th} leaf area	-6547.45	9.51	4^{th} leaf area X Blades area/plant	-308.51	0.45
Ear diameter X LAI X Blades area/plant	2.43	0.004	Ears dry wt./plant X Blades area/plant	249.79	0.36	4^{th} leaf area X LAI	81.54	0.12
Ear diameter X Migration coefficient	17.36	0.03	Ears dry wt./plant X LAI	-71.15	0.10	4^{th} leaf area X Migration coefficient	909.58	1.32
Ear length X No. of ears/plant	-413.84	0.60	Ears dry wt./plant X Migration coefficient	-841.18	1.22	Blades area/plant X LAI	1.04	0.002
Ear length X Ears dry wt./plant	15.74	0.023	No. of rows/ear X No. of kernels/row	-2104.55	3.06	Blades area/plant X Migration coefficient	7.85	0.01
Ear length X No. of rows/ear	117.19	0.17	No. of rows/ear X RPP_{kr}	333.91	0.49	LAI X Migration coefficient	-5.526	0.01
R2							1.00	99.85
Residual							0.00	0.15
Total							1.00	100.00

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