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ENVIRONMENTAL EFFECTS ON CORRELATION AND PATH COEFFICIENT ESTIMATES FOR THREE GROUPS OF AGRONOMIC TRAITS AFFECTING GRAIN YIELD OF SORGHUM

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ABSTRACT

To examine the influence of environment on the interrelationships between agronomic traits of grain sorghum affecting grain yield, 30 restorer and 20 maintainer lines were compared under two water regimes (normal irrigation and post-flowering stress) in two locations during the growing seasons of 2003 and 2004. The combined analysis for agronomic traits and yield components showed significant differences among the genotypes, locations, years and water regimes.

Correlation between studied traits generally displayed the same trend in the six environments. However, significant differences between water regimes for estimates that associations between number of green leaves and kernels/head, panicle length, plant height and grain yield/plant. Similarly, estimates of correlation coefficients were significantly different between locations for days to 50% heading and plant height, panicle width, grain yield/plant and kernel number/head and for the correlation between plant height with panicle length, and leaf area and number of green leaves. No significant differences were observed between correlation estimates due to year effects

Path coefficient analysis indicated the major role of the direct effects of kernels/head among the yield component traits. Panicle traits showed slight direct and indirect effects on grain yield with panicle width having the greatest direct effect. Morphological traits did not display any important direct effects on grain yield. Yield component traits accounted for 0.976 of the grain yield variation, and appeared to be most suitable for indirect selection for yield. Water stress increased the unknown factors affecting grain yield from 0.024 under normal moisture to 0.205 under water stress

Key words: ***Grain sorghum, Correlation, Path coefficient, Determination coefficient, Water stress, Yield components.***

INTRODUCTION

The degree of association between traits is important information for breeders to plan successful programs. Yield is the final performance of any crop and conditioned by a complicated genetic system. Thus improving simply inherited characters closely associated with yield would help improve yield. These characters can also be the main characters describing an ideotype for visual selection in early generations. Combinations of agronomic and quality traits with yield can be used to construct selection indices for multi-traits selection.

Plant breeders usually have to consider other agronomic and physiological traits such as plant height, 50% heading date, leaf area, number of seeds, and seed color in addition to yield. The amount of attention to be given to any of these criteria depends on the genetic nature of genotypes under improvement and the relationships among these traits. Knowledge on interrelationships between yield, plant height, 50% heading date, leaf area, number of seeds, and seeds colour is necessary for planning an efficient improvement program. Quinby (1963) showed that the increment in grain production due to heterosis in the productive hybrids is primarily due to increment in number of seeds/plant and partially to increments in seed size.

Mostafa *et al* (1992) reported that there was no significant relationship between days to 50% flowering and grain yield while plant height was significantly positively correlated with yield and 1000 grain yield. Correlations between different traits of sorghum were recorded by several breeders (Bittinger *et al* 1981, Webster 1983 and El-Kady *et al* 1996).

Several investigators used the path analysis to partition phenotypic and genotypic correlations to direct and indirect effects. The correlation coefficient simply measures mutual association without regard to causation while path analysis specifies the causes and their relative importance. El-Nagouly *et al* (1981) utilized genotypic and phenotypic variances and correlations in predicting the direct and indirect effects of four characters in a late maize population.

Singh and Baghel (1977) found that both number of grains per panicle and 1000 grain yield were major components of grain yield as indicated by their large positive direct effects. This information was utilized by different plant breeders (Eckebil *et al* 1977 and Patil *et al* 1985).

There is little information concerning the effect of environment interrelationships between agronomic traits of sorghum. Thus the present investigation was conducted to (1) estimate simple correlations among yield, yield components, panicle traits and morphological traits under normal moisture and post-flowering moisture stress in two locations and two seasons, (2) find out the effect of water stress and location on the correlation estimates, and (3) distinguish the direct and indirect effects of yield component, panicle trait and morphological characters on grain yield aiming to detect the most effective group of traits

MATERIALS AND METHODS

Twenty exotic male sterile (B-lines) and thirty restorer lines (R-lines) of sorghum were used to estimate phenotypic correlations among traits (Table, 1). The fieldwork of this study was conducted at Nubaria and South Tahrir, Agric. Res. Stations, (ARC), Egypt during 2003 and 2004 seasons. The genotypes were grown in a randomized complete block design (RCBD) with three replications under two water regimes i.e. (a) normal irrigation throughout the growing season and normal irrigation until booting stage followed by no irrigation until harvest. Each genotype was planted in one row plot, 4 meter long, and 0.7m wide. Planting was in hills spaced 20 cm apart with two plants/hill after thinning. Recommended agriculture practices were followed. The combined analysis of variance over water regimes, locations and years were done for days to 50% heading, plant height (cm), number of green leaves, leaf area (cm^2), peduncle length, panicle length (cm), panicle width (cm), kernel number, 1000 Kernel weight (gm) and grain yield/plant according to (Steel and Torrie, 1980). Path coefficient analysis was performed according to Singh and Chaudhary (1977). Three groups of traits (morphological traits, panicle dimensions and yield components) under the above conditions were used in the path analysis to find out the traits most effective on grain yield and the effect of environmental factors on the relationships between traits. Significant differences between estimates of the same association in different environments were determined according to Snedecor (1959).

Table 1. Pedigree of the thirty restorer lines (R lines) and twenty cytoplasmic male sterile maintainers (B lines) used in this study.

No	Pedigree of restorer lines	No	Pedigree of restorer lines	No	Pedigree of maintainer (B lines)	No	Pedigree of maintainers (B lines)
1	ICSR-16	16	ICSR 90011	1	BTX-1	16	BTX631
2	ICSR-21	17	ICSR 90014	2	ICSB-1	17	BTX635
3	ICSR-26	18	93MR 732	3	ICSB-14	18	BTX407
4	ICSR 89016	19	97MR 7112	4	ICSB-18	19	BTX409
5	ICSR 89022	20	90EO 328	5	ICSB-37	20	BTX807
6	ICSR 89025	21	90EO 362-4	6	ICSB-47		
7	ICSR 89027	22	RTX88V1080	7	ICSB-70		
8	ICSR 89028	23	RTX89V2084	8	ICSB88005		
9	ICSR 89029	24	82BDM 499	9	ICSB88006		
10	ICSR 89037	25	R 37-3	10	ICSB88007		
11	ICSR 89039	26	87EO366 sis	11	ICSB89002		
12	ICSR 90001	27	SC 170-14E	12	ICSB89003		
13	ICSR 90002	28	SC 414-12E	13	BTX2-1		
14	ICSR 90004	29	RTX 2862	14	BTX2-2		
15	ICSR 90010	30	RTX 2864	15	BTX629		

RESULTS AND DISCUSSION

Combined analysis of variance for agronomic traits and yield components were showed significant differences among genotypes, locations, years and water regimes (Table 2).

All genotypes x years and genotypes x locations interactions were significant for all studied traits except 1000-kernel weight and green leaf number. The interaction between genotypes and water treatments was not significant for all studied traits except panicle length and peduncle length. Leaf area and number of green leaves had reached the maximum growth before water stress was imposed, hence no significant interaction with water regimes would be expected.

The genotypes x water regimes x locations x years interactions were significant for all traits indicating that performance of genotypes varied with locations, water supply and years. There results were in harmony with those reported by Hoffmann *et al* (1984).

Correlation

Phenotypic correlation coefficients were estimated for all possible relationships under various conditions viz., normal and water stressed conditions, Nubaria and South Tahrir locations and first and second seasons (Table 3 a, b and c). The grain yield showed significant positive association with kernel number/head, number of green leaves, panicle width, plant height, heading date, panicle length and leaf area under normal conditions. But the 1000 kernel weight, which is one of the principal yield components, did not show significant association with yield under water stress. Significant interrelationships of both positive and negative directions among those characters that displayed close association with grain yield are presented in Table (3a). This trend of association apparently appeared in the other studied environments with some significant differences for the correlated estimates between normal and water stress conditions and between the two location conditions, while there were no significant differences between correlations estimates can be due to year effects in the present study (Table 3c).

Among 45 association relationships 10 of them displayed sensitivity to environmental conditions that would significantly change the correlation estimates as response to their environmental factors. While the remainder relationships proved to be stable over environments (Table 3 a, b and c). Four pairs of the 10 sensitive relations significantly displayed different correlation estimates under water stress and normal water condition, number

Table 2. Mean squares from combined analysis of variance over two water regimes, two seasons and two locations for sorghum traits.

Source of variance	df	HD	PLH	NGL	LA	PDL	PnL	PnW	KN	1000 KW	GY
Years (Y)	1	32.34**	35773.92**	285.19**	174870.16**	113.47**	1532.25**	453.87**	347972238.03**	16394.72**	4070.08**
Locations (L)	1	10650.52**	94128.65**	649.74**	1337069.28**	305.02**	2827.47**	167.25**	277775594.25**	1746.05**	22102.08**
Y x L	1	747.34**	2569.61**	321.37**	1610.08	0.02	40.33**	1.47	85900673.2**	7427.68**	2350.08**
Error a	8	6.03*	58.57	42.74**	9732.88**	1.48**	1.92	7.11**	2564660.41*	41.72	836.52**
Water stress (WS)	1	63.94**	3873.61**	1077.31**	958240.08**	85.87**	2363.21**	161.33**	5829986.8*	2728.58**	35534.08**
Y x WS	1	20.54**	147	23.8	0.21	3.52**	45.63**	2.18	297171.21	96.62	2670.08**
L x WS	1	6.02	40.33	16.57	112714.08**	13.87**	41.81**	0.21	2617628.43	222.31**	216.75
Y x L x WS	1	5.47	367.41**	41.44	512.21	0.04	1.76	0.4	37678390.41**	238.08**	3570.75**
Genotypes (G)	49	175.91**	6747.93**	23.21**	65356.04**	10.72**	76.6**	4.73**	12572064.81**	90.02**	3782.03**
Y x G	49	26.49**	587.99**	21.65*	9212.68**	0.98**	15.89**	0.92**	2228706.48**	36.2	163.75**
L x G	49	99.14**	185.52**	14.54	18010.08**	5.81**	22.17**	1.59**	3498889.39**	58.09**	475.68**
Y x L x G	49	21.06**	172.83**	11.28	8921.51**	0.67**	9.62**	0.77*	2366190.49**	40.75*	173.75**
WS x G	49	1.46	30.02	17.68	3437.78	1.48**	5.75**	0.53	1270821.66	24.34	66.86
Y x WS x G	49	1.54	29.77	14.49	2137.62	0.34	2.82	0.46	991848.73	24.73	24.29
L x WS x G	49	2.06	23.41	12.81	2777.78	1.9**	2.74	0.63	1011544.97	28.29	49.87
Y x L x WS x G	49	2.1	28.14	13.41	1728.33	0.34	3.05	0.39	801228.34	24.88	35.16
Error	792	2.67	45.84	14.11	2618.61	0.33	3.25	0.55	1084884.60	28.20	69.87

HD= days to 50% heading, PLH= plant height, LA= leaf area, NGL= number of green leaf, PnL= panicle length, PnW=panicle width, PDL= Peduncle length, 1000KW= 1000 kernel weight, Kn= kernel number/head, GY= grain yield/plant.

***and ** significant at 0.05 and 0.01 probability levels, respectively.**

Table 3 a-c. The effect of water regime, location and year on phenotypic correlation coefficient among sorghum traits.

a) Normal conditions above and water stress below diagonal

Traits	Days to 50% heading	Plant height	No of green leaf	Leaf area	Peduncle length	Panicle length	Panicle width	Kernel number	1000 Kernel weight	Grain Yield /plant
Days to 50% heading	-	0.49	-0.03	0.19	-0.23	0.03	0.27	0.43	-0.11	0.43
Plant height	0.50	-	0.47	0.41	-0.38	0.26	0.60	0.64	0.15	0.64
No of green leaf	0.32	0.06 *	-	0.31	-0.34	-0.03 **	0.15	0.64 *	0.07	0.70
Leaf area	0.18	0.36	0.013	-	-0.22	0.25	0.33	0.25	0.04	0.40
Peduncle length	-0.18	-0.28	-0.15	-0.19	-	0.03	-0.24	-0.31	0.08	-0.27
Panicle length	0.07	0.09	0.27	0.26	-0.11	-	0.29	0.22	0.04	0.41
Panicle width	0.28	0.47	0.67	0.32	-0.34	0.14	-	0.55	0.13	0.69
Kernel number	0.48	0.55	0.23	0.26	-.26	0.19	0.51	-	-0.45	0.92
1000 kernel weight	0.03	-0.08	-0.22	0.16	0.02	-0.03	0.18	-0.17	-	0.08
Grain yield/plant	0.48	0.58	0.17 **	0.43	-0.32	0.23	0.67	0.86	-0.08	-

b) Nubaria above and south El-Tahrir below diagonal

Traits	Days to 50% heading	Plant height	No of green leaf	Leaf area	Peduncle length	Panicle length	Panicle width	Kernel number	1000 Kernel weight	Grain Yield /plant
Days to 50% heading	-	0.67**	0.17	0.29	-0.14	0.18	0.59**	0.14	0.08	0.63**
Plant height	0.12	-	0.45	0.34	-0.32	-0.07	0.31	0.48	0.06	0.53
No of green leaf	0.08	0.11	-	0.49	-0.38	0.03	0.2 0	0.54	-0.14	0.56
Leaf area	-0.01	0.35	-0.04 **	-	-0.33	0.27	0.30	0.20	0.04	0.29
Peduncle length	-0.17	-0.22	-0.18	-0.07	-	-0.13	-0.19	-0.21	0.01	-0.21
Panicle length	-0.03	0.31	0.17	0.22	0.02	-	0.18	0.17	-0.02	0.20
Panicle width	-0.09	0.65*	0.50	0.33	-0.36	0.19	-	0.26	0.19	0.45
Kernel number	0.56*	0.63	0.27	0.20	-0.23	0.27	0.55	-	-0.26	0.89
1000 kernel weight	0.01	0.07	-0.09	0.20	0.07	-0.08	0.05	-0.41	-	0.11
Grain yield/plant	0.14	0.62	0.27	0.40	-0.24	0.38	0.66	0.85	-0.05	-

c) Season of 2003 above and season of 2004 below diagonal

Traits	Days to 50% heading	Plant height	No of green leaf	Leaf area	Peduncle length	Panicle length	Panicle width	Kernel number	1000 Kernel weight	Grain Yield /plant
Days to 50% heading	-	0.38	0.04	0.07	-0.18	0.12	0.15	0.38	-0.10	0.42
Plant height	0.55	-	0.47	0.39	-0.39	0.09	0.48	0.66	-0.02	0.59
No of green leaf	0.27	0.03	-	0.40	-0.44	0.11	0.04	0.48	-0.38	0.59
Leaf area	0.33	0.31	-0.01	-	-0.25	0.12	0.19	0.29	0.01	0.52
Peduncle length	-0.18	-0.24	-0.07	-0.20	-	-0.10	-0.33	-0.35	0.08	-0.28
Panicle length	-0.07	0.21	0.04	0.28	-0.04	-	0.19	0.03	-0.10	0.22
Panicle width	0.38	0.50	0.50	0.36	-0.27	0.22	-	0.43	-0.02	0.62
Kernel number	0.44	0.51	0.28	0.10	-0.25	0.30	0.47	-	-0.03	0.92
1000 kernel weight	0.02	0.12	-0.27	0.24	0.15	0.14	0.25	-0.26	-	0.04
Grain yield/plant	0.43	0.58	0.22	0.25	-0.32	0.40	0.62	0.79	-0.05	-

* and ** it is significantly differ than their counterpart estimate upper diagonal at 0.05 and 0.01 probability levels, respectively.
r=0.280, P<0.05 and r=0.357, P<0.01

of green leaves with kernels/head (0.23 to 0.64), panicle length (0.27 to −0.03), plant height (0.47 to 0.06), and grain yield/plant (0.70 to 0.17), Table (3a). Apparently, the number of green leaves was common in those pairs. The depression of green leaves number under water stress conditions was reported by Al-Naggar *et al* (1999). El- Bakry *et al* (2003) stated that the speed of senescence of sorghum leaves increased by post flowering water stress. Thus the low number of green leaves as well as deficiency of senescence leaves masked these associations.

Six pairs significantly displayed different correlation estimates under Nubaria and south El-Tahrir conditions (Table 3b) i.e., (days to 50% heading and plant height from 0.67 to 0.12), (days to 50% heading and panicle width from 0.59 to -0.09), (days to 50% heading and grain yield/plant from 0.63 to 0.14), (days to 50% heading and kernels/head from 0.56 to 0.14), (between plant height and panicle length from 0.65 to 0.31) and (leaf area and number of green leaves from -0.04 to 0.49). The distance between the two locations is about 60 kilometers that suggest similar agroclimatological factors between them. Thus the difference may be due to soil conditions. The apparent difference between these two locations is the salinity level, which was more in south El-Tahrir than in Nubaria soil (El- Bakry *et al* 2003). Again, some correlation estimates between associated traits were changed to be non-significant under stress conditions. Wery *et al* (1994) discussed that, reduction of leaf area and number of green leaves is an important adaptive mechanism for salinity stress and it is usually the first strategy a plant adapts when water becomes limitary. Severe water stress caused the older leaves of plants to senescence early, leaving only the younger leaves to support the plant. They added that the loss of the older leaves appears to be an effective adaptation to water stress since the area of transpiration is decreased but the top leaves, which are more active in photosynthesis, are retained. Moreover reduced leaf growth and accelerated leaf senescence are common response to water deficits and they both reduce leaf area. These results are in agreement with those of Meiri and Pojakaff - Mayber (1970), they found that the number of leaves developing on plant under stress condition were usually smaller than those on the control plants. This discussion may illustrate the highly significant correlation between leaf area and number of green leaves under stress conditions at south El-Tahrir.

Comparing, the salinity stress conditions at south El-Tahrir, which began very early in plant growth with post-flowering water stress that extended from flowering until maturity may explain differences observed among associations. El Hawary (1986), Uiery and Frederick (1997) and Mourad *et al* (1999) reported that early heading and short periods to anthesis are most important mechanisms of tolerance to stress conditions.

The results shown in (Table 3c) revealed that there were no significant differences between correlation estimates between seasons.

Path coefficients

To identify traits most effective on grain yield to use them in characterizing the sorghum plant ideotype for visual selection, to determine the direct and indirect causes of associations and to permit a critical examination of the specific forces acting to produce a given correlation, the phenotypic path coefficients were obtained for three groups of agronomic traits affecting grain yield.

Figure (1) showed the path coefficients diagram of yield component traits that represents the direct effects and interrelationships between them.

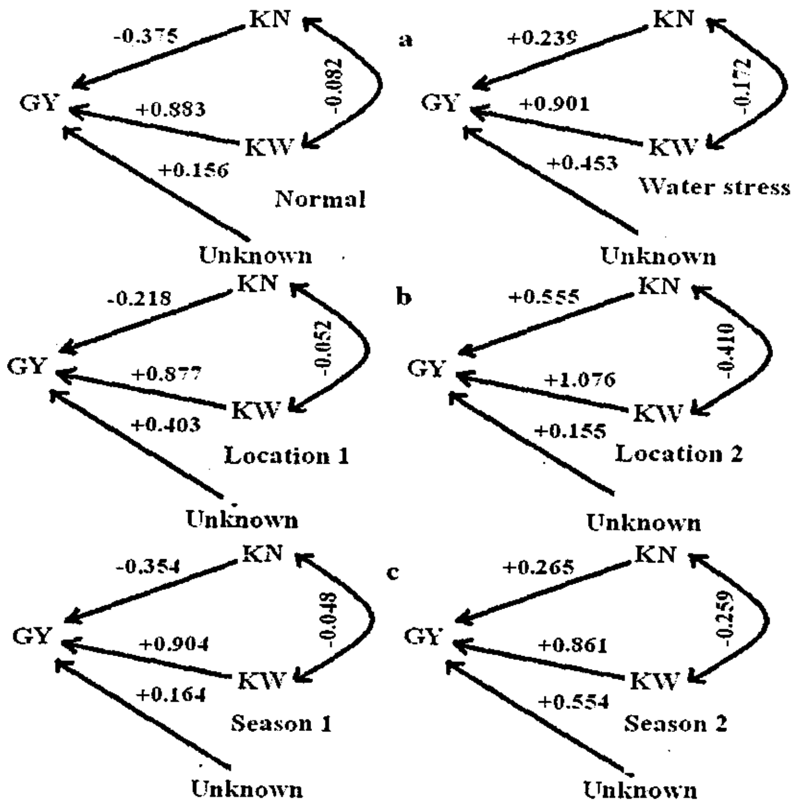

Fig 1.A diagram of traits affecting sorghum grain yield (1) under two water regimes, (2) two locations and (3) two seasons.

Kernel number/head proved to be the major yield component since its main effect of path coefficients on grain yield/plant ranged from 0.861 to 1.076 while the path coefficient of kernel weight on grain yield/plant ranged from -0.375 to 0.555. Unfortunately the indirect effect via each of kernel weight on kernel number had negative phenotypic correlation under three tested cases (stress, location and season), it ranged from -0.41 to -0.048 that suggests the selection for these components must depend on selection index respecting the interrelationship and the relative economic importance of them. However, the path coefficients due to unknown factors after these two yield component ranged from 0.115 to 0.554. It is clear that water stress dramatically raised the path coefficients of unknown effects, which suggests that normal moisture conditions are more effective for selection.

The path coefficient diagram shown in Figure (2) represents the direct effects and interrelationships between panicle traits affecting grain yield.

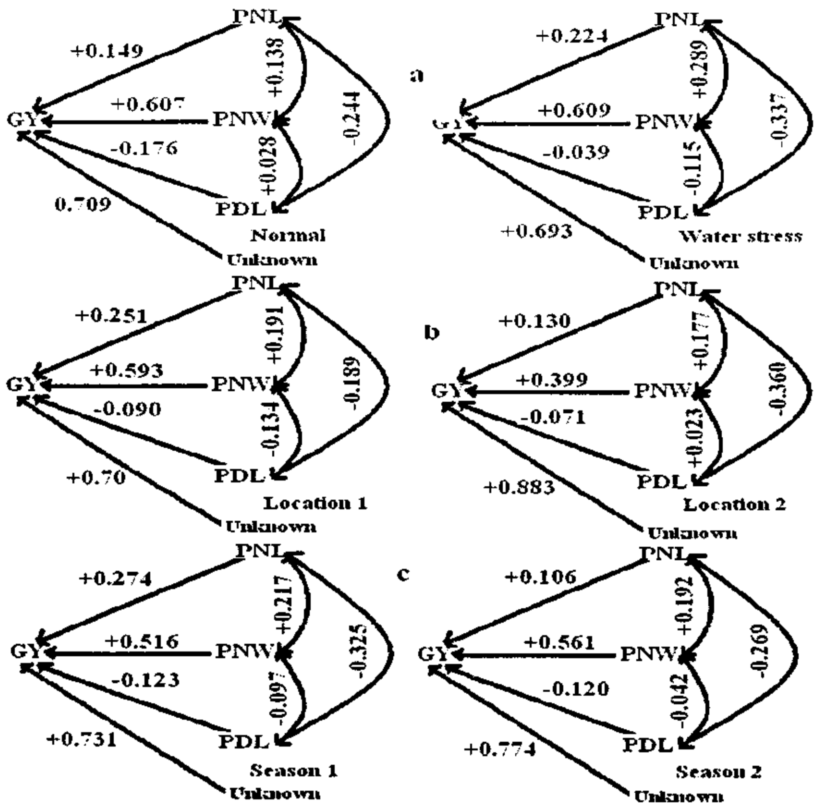

Fig 2.A path diagram for the effects of panicle traits on grain yield/plant (1) under two water regimes, (2) two locations and (3) two seasons.

The most effective path coefficient affecting grain yield was accounted for by panicle width; it ranged from 0.399 to 0.609. This result agrees with breeders experience because it mainly depends on seed setting, kernel number and kernel size. The panicle length also gave slightly direct effects on grain yield/plant ranging from 0.106 to 0.274. Thus, these direct effects combined with indirect effects via panicle width and peduncle length, which had opposite interrelationships, to be significant in some cases and non-significant in other cases (Table 3). The peduncle length displayed negative path coefficients ranging from -0.176 to -0.039; these direct effects combined with non-direct effects via other panicle traits to show some significant and negative correlations with grain yield. However, peduncle length is as important trait under rainy conditions that decreases withering injury and for hybrid seed production utilizing male sterility. This relationship between peduncle lengths and grain yield needs more investigation. Nevertheless, the path coefficients of unknown factors were greater than all known factors and ranged from 0.693 to 0.883. These results clarify that panicle traits are not enough for identifying productive genotypes, but can be used to describe the plant ideotype.

The morphological characters and the direct and non-direct effects on grain yield/plant are displayed in Figure (3). These characters significantly associated with grain yield/plant under normal conditions since the correlation estimates were, 0.64**, 0.40*, 0.70** and 0.43** for plant height, leaf area, number of green leaves and days to 50% heading, respectively. Nevertheless, the path coefficients ranged between 0.275: 0.461, -0.041: 0.250, 0.146: 0.480 and 0.061: 0.330 for plant height, leaf area, number of green leaves and days to 50% heading, respectively. Clearly, the direct effects represented, as path coefficient was smaller than correlation estimates; the remainder due to the indirect effects via the interrelationships between the causal factors. Examination of these interrelationships reveals unreal association between leaf area with number of green leaves, which ranged from negative estimate -0.037 to significant positive estimate 0.494** since the leaf area is the accumulation of all leaves areas or simply the number of leaves times the average area of individual leaves. It seems that to estimate leaf area as leaf length x maximum leaf width x leaf number is not suitable under stress because of leaf mortality and fall. The un-described factors showed great path coefficients ranging from 0.602 to 0.764, indicating that the morphological characters alone are unsuitable for indirect selection. Since under stress conditions, such as water stress, the path coefficient of unknown factors decreased and the path coefficient of number of green leaves increased the latter character must receive more consideration.

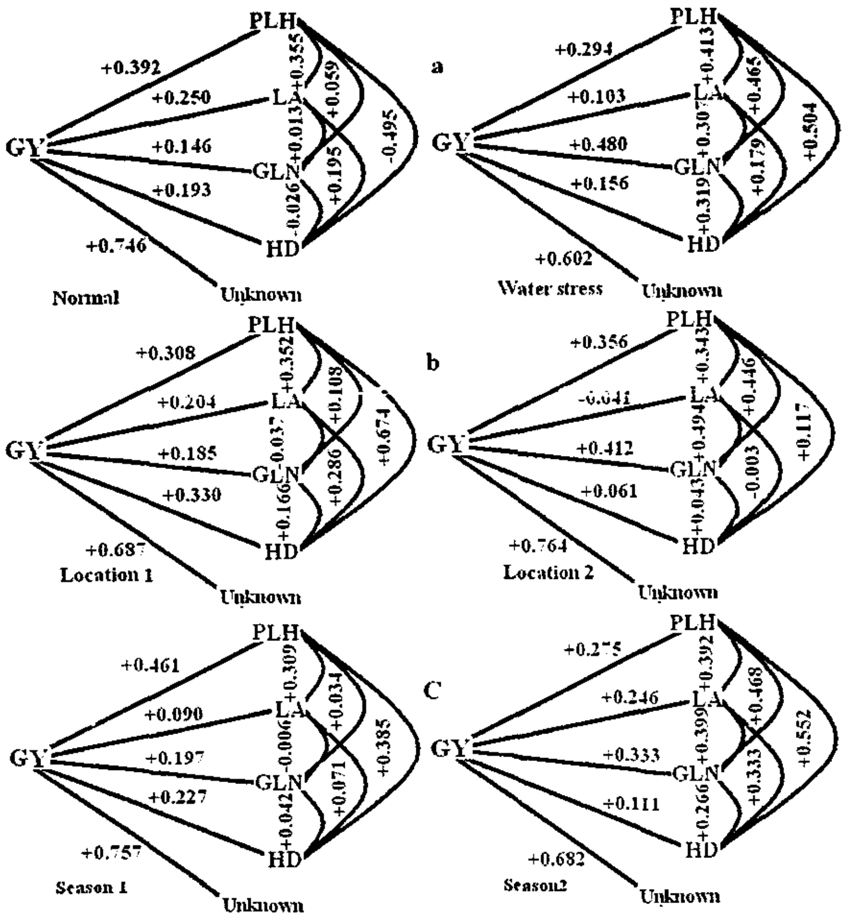

Fig 3. A path diagram and for the effects of morphological traits on grain yield/plant (1) under two water regimes, (2) two locations and (3) two seasons.

Finally the results suggest that the selection for morphological traits would be less effective than other traits. Also there are some morphological traits that showed strong association with drought resistance in sorghum such as stay green. The stay green trait in sorghum has been suggested as indirect selection criterion for post flowering drought tolerance (Rosenow *et al* 1983). Similar results were obtained by El Bakry *et al* (2003), who indicated that the stay green score expresses the senescence rate; the useful effect of stay green on grain yield/plant under water stress was indicated by a strong negative correlation coefficient. So the highest stay green score and lowest senescence rate gives the highest grain yield under post flowering water stress condition.

Determination coefficients

When the whole unit is the variation of the dependant variable the determination coefficient is the portion due to an independent variable. Results in Table (4) showed different portions of grain yield variations after partitioning it to direct effects of causal traits, indirect effects due to the interrelationships between causal traits and the remainder portion under different environments.

Table 4. Determination coefficients of yield components, panicle traits and plant morphological traits affecting grain yield.

System	Trait	Water treatment		Year		Location	
		Normal	Water stress	Season1	Season2	Location1	Location 2
Yield components	1000 KW	0.141	0.057	0.125	0.070	0.048	0.308
	KN	0.780	0.812	0.817	0.740	0.770	1.157
	KW.KN	0.055	-0.074	0.031	-0.118	0.020	-0.489
	Unknown	0.024	0.205	0.027	0.307	0.163	0.024
Panicle traits	PnL	0.022	0.050	0.075	0.011	0.063	0.017
	PnW	0.368	0.371	0.266	0.315	0.352	0.159
	PDL	0.031	0.002	0.015	0.014	0.008	0.005
	PnL.PnW	0.025	0.079	0.061	0.023	0.057	0.018
	PnL.PDL	-0.001	0.002	0.007	0.001	0.006	0.000
	PnW.PDL	0.052	0.016	0.041	0.036	0.020	0.021
	Unknown	0.502	0.480	0.535	0.599	0.494	0.780
Plant morphological traits	PLH	0.153	0.086	0.213	0.076	0.095	0.127
	NGL	0.021	0.230	0.039	0.111	0.034	0.170
	LA	0.063	0.011	0.008	0.061	0.042	0.002
	HD	0.037	0.024	0.050	0.012	0.109	0.004
	PLH.NGL	0.007	0.131	0.006	0.086	0.012	0.131
	PLH.LA	0.070	0.025	0.026	0.053	0.044	-0.010
	PLH.HD	0.075	0.046	0.080	0.034	0.137	0.005
	NGL.LA	0.001	0.030	0.000	0.065	-0.003	-0.017
	NGL.HD	-0.001	0.048	0.004	0.020	0.020	0.004
	LA.HD	0.019	0.006	0.003	0.018	0.038	0.000
	Unknown	0.556	0.363	0.573	0.465	0.471	0.584

HD= days to 50% heading, PLH= plant height, LA= leaf area, NGL= number of green leaf, PnL= panicle length, PnW=panicle width, PDL= Peduncle length, 1000KW= 1000 kernel weight, Kn= kernel number/head, GY= grain yield/plant.
***and ** significant at 0.05 and 0.01 probability levels, respectively.**

Regarding the yield components under normal conditions, the direct effect as determination coefficient attributed to kernel number was 0.78, indicating the major role of kernel number/head on detecting grain yield/plant. On the other hand, 1000 kernel weight variation directly influences grain yield/plant variation about 0.141 and the indirect effects participated by a portions about 0.055. The remainder portion due to unknown factors was trivial (0.024) indicating the efficiency of yield components under normal conditions for indirect selection. On the other hand, the remainder was increased under water stress conditions (0.205). Similar trends can be observed with other stresses.

Panicle width proved that to be the most important characteristic of productive plants regarding head traits. However, the remainder portion of the grain yield variation after panicle traits ranged from 0.48 to 0.78 suggesting that the head traits only are unsuitable for indirect selection for grain yield/plant. Similar results can be deduced from morphological traits where the remainder portion ranged from 0.363 to 0.584. But here the remainder was decreased under water stress conditions and was accompanied with increased direct effects of number of green leaves estimated as determination coefficient from 0.021 to 0.230. This result clarifies the importance of green leaves number as indicator for plant tolerance to water stress. This finding is in agreement with El Bakry *et al* (2003).

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التأثيرات البيئية علي الارتباط ومعامل المرور المقدرين علي ثلاثة مجا ميع من الصفات المحصولية المؤثرة علي محصول حبوب الذرة الرفيعة

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أجريت تجربتان حقليتان بمحطتي بحوث جنوب التحرير والنوبارية لتقييم ٣٠ سلالة خصبة و٢٠ سلالة معيدة للخصوبة تحت ظروف مستويين من الري (كنترول – بعد التزهير) وفي موسمين متتاليين ٢٠٠٣-٢٠٠٤ لدراسة الارتباط المظهري بين محصول الحبوب والصفات المساهمة فيه وكذلك تحليل معامل المرور لمعرفة التأثيرات المباشرة وغير المباشرة علي المحصول وتحديد مساهمتها النسبية فيه

أظهرت نتائج تحليل التباين المشترك اختلافات معنوية بين التراكيب الوراثية والسنين ومستويات الري لجميع الصفات تحت الدراسة.

أظهرت النتائج تشابه في قيم الارتباط المقدرة تحت ظروف البيئة الستة ماعدا وجود أربع اختلافات معنوية بين قيم الارتباط تحت مستويات الري وهي المتلازمات بين عدد الأوراق الخضراء مع كل من عدد الحبوب/قنديل – طول القنديل وطول النبات ووزن الحبوب/نبات. وستة ارتباطات أظهرت اختلفت معنويا بين موقعي الدراسة وكانت هذه الارتباطات بين ٥٠% تزهير وكل من طول النبات، عرض القنديل، وزن الحبوب/نبات عدد حبوب القنديل وكلا من الارتباطات بين طول النبات و طول القنديل وبين مساحة الورقة وعدد الأوراق الخضراء. كما أظهرت النتائج عدم وجود اختلافات معنوية في قيم الارتباط تحت تأثير السنيين.

أوضحت النتائج المتحصل عليها بدراسة معامل المرور لمكونات المحصول (المجموعة الأولى) ان عدد الحبوب/قنديل هي أكثر الصفات التي لها تأثير مباشر. أما بالنسبة لصفات القنديل (المجموعة الثانية) فكان لها تأثير مباشر وغير مباشر علي صفة المحصول ولكن عرض القنديل لها أحسن تأثير مباشر. أما المجموعة الثالثة من الصفات المورفولوجية لا تشترك بأي تأثير مباشر معنوي علي إنتاجية المحصول.

أظهرت دراسة معامل التحديد أن مكونات المحصول تصف ٩٧,٦% من تباين المحصول. وبذلك تعتبر اكثر مجموعات الصفات التي يجب أن تحظى باهتمام المربي عند الانتخاب غير المباشر للمحصول. وعموما يؤدي تأثير الإجهاد المائي إلى زيادة النسبة الراجعة للعوامل غير المحددة التي تؤثر علي المحصول حيث زادت من ٢,٤% تحت ظروف المقارنة الي٥,٢٠% تحت ظروف الإجهاد المائي.