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The Simple Correlation and Path Coefficient Analysis for Yield and Some Yield Components of Durum Wheat in Two Seasons in Iraqi Kurdistan

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Abstract

This investigation was conducted during the winter seasons of 2012-2013 and 2013-2014 at Qlyasan Agriculture Research Station, Faculty of Agricultural sciences, University of Sulaimani, using split plot design the main plots conducted in Randomized Completely Block Design (RCBD) with three replicates to study the effect of organic matter and removal treatments on the yield of durum wheat Ovanto cultivars. Highly significant and positive correlations recorded between grain yield & spike weight, grain weight/spike and harvest index at the first season. At the second season highly significant and positive correlation were recorded between grain yield and spike weight and harvest index and significant and positive correlation with spike length and biological yield at the second season. Concerning the path coefficient analysis, grain yield represented the dependent variable and no. of spikes/m^2, spike weight/m^2, average spike length, no. of spikelets/spike, no. of grains/spike, grains weight/spike,1000-grain weight, biological yield (t/ha) , harvest index and grain yield (t/ha), were the independent ones. Maximum and positive direct effect in grain yield recorded by grain weight/spike at the first season and harvest index at the second season reaching 0.639 and 0.822 respectively.

Introduction:

The cultivation of durum wheat gave greater yield than other wheat in the areas of low precipitation (3–5 dm). Good yields can be obtained by irrigation, but this is seldom done. In the first half of the 20th century ***[1]***, in wheat; many breeders attempt to illuminate the relations between grain yield and agronomic and morphological traits by using simple correlation coefficients. Although path coefficient is very important to determine traits that direct affect in grain yield, they are inadequate to determine indirect effect of these traits on grain yields ***[2]*** and ***[3]***. These circumstances are more common in cereals, because of yield traits that occur at a diverse growing stage and affect each other, especially where early occurring traits influence later traits ***[4]***. There was a dynamic balance among yield traits, which avoid improvement of grain yield through selection for just one yield trait ***[5]***. Some yield components significantly affect grain yield through effect at different growing stages from sowing to harvest. Many of previous studies indicated that plant height, the number of grains per spike, the grain weight per spike, 1000 grain weight and test weight were primary components of grain yield in cereal crops ***[6], [7], [8], [9], [10], [11], [12]*** and ***[13]***.
Selection for grain yield is improvement can only be effective if sufficient genetic variability is present in the genetic material ***[14]***. Genotypic association is important in determining the stage to which various yield-contributing parameters are associated with grain yield plant $^{-1}$ ***[15]***. Yield, as a part of various components, is an intricate character. It was suggested that yield depends on the number of spikes per unit area, the number of kernels per spike and the average kernel weight ***[16]***. It has been propose that yield components have either a direct or indirect effect on grain yield or both. Therefore, it was grounds to determine the effects of yield components on grain yield. Subsequently, the most common statistical method used for this purpose is path

coefficient analysis. Path coefficient analysis is a dependable statistical technique ***[17]***. Agronomists in field crops have commonly use path coefficient analysis to explain obviously the relations between yield and yield components ***[2], [17], [18], [19], [20], [21], [22], [23], [24], [25], [26]*** and ***[27]***. In agriculture, path-coefficient analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield ***[13], [17], [26], [28]*** and ***[29]***.

Material and Methods:

This investigation was conducted during the winter seasons of 2012-2013 and 2013-2014 at Qlyasan Agriculture Research Station, Faculty of Agricultural sciences, University of Sulaimani, 2 km north western of Sulaimani city (35° 34′ 307″ N and 45° 21′ 992″ E with an altitude of 765 masl), using split plot design the organic matter was implemented in the main plots and conducted in Randomized Completely Block Design (RCBD) with three replicates to study the effect of organic matter and removal treatments on the yield of durum wheat Ovanto cultivars which has been provided by Bakrajo Research Center in Sulaimani and the compost was provided by Erbil Agriculture Research Center which contains (E.C. 0.19 $ds.m^{-1}$, N 2%, P 2.5%, K 2.1%, O.M 60%, Moisture 40% and pH 7.5%) and applied in 4 levels (0, 4, 8, and 12) ton/ha. The second factor was removing the photosynthetic organs (leaf and awn) used as 4 levels (No removal, flag leaf blade removal, awns removal, and flag leaf blade + awns removal) which implemented in the sub-plots. Each sub-plot consisted of four rows, 3 m long, and 0.25 m between rows. Five plants from each treatment combination were selected randomly and data were recorded on no. of spikes/m^2, spike weight/m^2, spike length (cm), no. of spikelets/spike, no. of grains/spike, grains weight/spike (g), 1000-Grain weight (g), biological yield (t/ha), harvest index (H.I) and grain yield (t/ha). The correlation coefficients were calculated to determine the degree of association of the yield and the other characters with also among the yield components themselves in Phenotypic correlations were computed by using the formula given by Singh and Chaudhary (1985) ***[30]*** and ***[31]***. The path coefficient techniques involve partitioning of correlation coefficient to determine direct (unidirectional path way `P') and indirect effects through alternate path ways (Path way `P' X correlation coefficient `r') of various variables and grain yield per plant. Grain yield was considered as the resultant variable and the others as causal variables. The path coefficient analysis was carried according to the equations as suggested by Singh and Chaudhary (1985) ***[31]*** through (Analysis of Moment Structures) AMOS Ver. 18 Software.

Result and Discussion:

Data in Tables (1) shows the character means under this study for both seasons 2012-2013 and 2013-2014 respectively, the interaction between the applications of 8t/ ha/ awn remove treatment produced maximum number of spikes/ m^2 at both seasons recording 491.333 and 506.667 spikes respectively. Maximum spike weight recorded by the treatment of control at both seasons reaching 1476.333 and 1473.333 gm respectively. Maximum spike length at the first season reached 7.487 cm by the interaction of the application of 4t/ ha/ flag leaf blade remove, while at the second season reached 6.667 cm by the interaction of the application of 12t/ ha/ both removing. Regarding to the number of spikelet/ spike the treatment of 12t/ ha/ both removing recorded the highest value reached 21.000 spikelet at the first season, while at the second season it was reached to 18.967 recorded by the interaction between the application of 8 t/ ha/ awn removing treatment. The highest number of grain/ spike was 58.767 grains recorded the interaction of the application of 4t/ ha/ flag leaf blade removing at the first season, while at the second season it was 56.900 grains recorded by the interaction between the application of 8t/ ha/ awn removing. Concerning of grain weight/ spike the treatment of control exhibited maximum value at the first season 2.542 gm, while at the second season it was 2.703 gm recording by the interaction between the application of 8t/ ha/ awn removing. The interaction between the application of 4t/ ha/ flag leaf blade removing recorded maximum 1000 grain weight reached 51.333 at the first season, while at the second season it was reached to 50.300 gm recorded by the treatment of control. The highest biological yield reached 22.155 t/ ha by the interaction between 8t/ ha/ both removing at the first season, while at the second season it was 21.903 t/h recorded by the treatment of control. Maximum harvest index value recorded by the interaction between 12t / h/ both removing reached 0.506 at the first season, while at the second season it was 0.531 recorded by the treatment of control. In wheat, the leaves especially the flag leaves have been considered to be the key organs contributing to higher yields. More to the point, their results suggested that awns play a dominant role in contributing to large grains and high grain yield in awned wheat cultivars, particularly during the grain filling stage ***[32]***.

The Correlation coefficients among grain yield and its important components was represented in Table (2) in the first season 2012-2013, number of spikes/m^2 recorded high significantly and negatively correlative with number of spike length (-0.646) and significantly and negatively with the number of grains/spikes (-0.499) and 1000 grain weight (-0.537). Spike weight gave positive and highly significant correlation with harvest index (0.765) and grain yield (0.849), while it recorded significant and positive correlation with the characters grain weight/spike (0.560) and biological yield (0.597). Spike length (cm) recorded highly significant and positive correlation with number of spikelets/spike (0.910), number of grains/spike (0.880), grain weight/spike (0.739) and 1000 grain weight (0.851). Number of spikelets/spike was recorded highly significantly and positive correlation with 1000 grain weight (0.924), number of grains/spike (0.917), and grain weight/spike (0.764) and significant and positive correlation with grain yield (0.531). Number of grains/spike exhibited positive and highly significantly correlation with 1000 grain weight/spike (0.915) and grain weight/spike (0.806) and significant and positive correlation with grain yield (0.527). Grain weight/spike was recorded highly significant and positively with 1000 grain weight (0.728), harvest index (0.752) and grain yield (0.799). Harvest index was recorded highly significant and positive correlation with grain yield (0.822). A positive correlation was found between the weight of grain per plant and the productive tillering. For yield of grain in durum wheat are great productive tillering and grain yield of plants ***[33]***.

The Correlation coefficients among grain yield and its important components was represented in Table (3) in the second season 2013-2014.Number of spikes/m^2 correlated significantly and positively with biological yield (0.533). Spike weight was recorded high significantly and positively correlated with grain yield (0.893) and harvest index (0.655) and correlated significantly and positively with spike length (0.571) and biological yield (0.532). Spike length recorded significant and positive correlation with number of spikelets/spike (0.606), 1000 grain weight (0.599) and grain yield (0.583). Number of spikelets/spike gave significant and positive correlation with number of grains/spike (0.571). Highly significant and positive correlation was recorded between number of grains/spike and grain weight/spike (0.752).1000 grain weight gave significant and positive correlation with harvest index (0.518). Biological yield recorded significant and positive correlation with grain yield (0.589). Highly significantly and positive correlation were recorded between harvest index and grain yield (0.731). The grain yield is a complex traits which is influenced by many factors, would be plant breeders interested to know the nature of the relationship and the kind between these traits, especially under farming conditions, where the water is main limiting factor in many areas of wheat production around the world due to uneven rainfall distribution during the growing season, so it is important the characterized cultivars cultivated in these areas in the exceeded rendering of grain yield and its components under the limited and non- limited of moisture conditions ***[34]***.

Data in Table (4) explain the values of the path coefficient analysis indicating to direct and indirect effect of grain yield components in grain yield. At the first season maximum positive direct effect in grain yield produced by grain weight/spike which was 0.639 and followed by number of spike/m^2 which was 0.356. Maximum negative direct effect in grain yield was -0.158 recorded by number of grains/spike. Maximum positive indirect effect in grain yield was -0.515 recorded by number of grains/spike via grain weight/spike, while maximum negative indirect effect was -0.293 recorded by number of spike/ m^2 via grain weight/spike.

The correlations among grain number per spike, grain weight per spike, 1000 grain weight and grain yield as well as direct and indirect effects of those traits on the grain yield were investigated using path analysis. Grain number per spike, 1000-grain weight, plant height and test weight had significant direct effect on grain yield. It was ideal that these characteristics could be important selection criteria in durum wheat breeding studies ***[35]***. Grain yield showed positive phenotypic correlation with above-ground biomass, number of spikes

m^{-2} and number of grains per spike. Path analysis revealed positive direct effect and moderate correlation of number of spike m-^{2} and number of grains per spike with grain yield ***[36]***.

Data in Table (5) explain the path coefficient analysis at the second season. Harvest index recorded maximum positive direct effect in grain yield recorded 0.822 and followed by biological yield with 0.664. Spike length with -0.33recorded maximum negative direct effects in grain yield. The character spike weight recorded maximum positive indirect effect in grain yield via harvest index reaching 0.538, while maximum negative indirect effect recorded by biological yield reaching -0.095. In the correlation study, the spike weight, harvest index and biological yield were the main plant traits related to grain yield increase, while in the path analysis its importance was secondary. The path coefficient analysis showed that harvest index and biological yield had the maximum positive direct effect on grain yield in durum wheat ***[37]***.

Table 1: Means of the studied character at 2012-2013 and 2013-2014 seasons

Treatment combinations	No. of spikes /m²	Spike weight (g/m²)	Spike length (cm)	No. of spikelets/ spike	No. of grains /spike	Grain weight /spike (g)	1000-grain weight (g)	Bio. yield (ton/ha)	Harvest index
2012-2013 Season									
0 t/ ha Control	374.000	1209.000	7.167	20.183	53.937	2.542	48.027	21.100	0.451
4 t/ ha / Flag leaf blade	389.333	1053.667	7.000	16.900	46.537	1.915	41.333	17.470	0.427
8 t/ ha / Awn	485.667	1234.000	3.930	11.890	36.000	1.719	31.067	18.042	0.461
12 t/ha / both	470.333	1295.333	5.757	14.517	43.047	2.106	34.000	19.429	0.506
0 t/ ha Control	465.667	1389.667	5.273	15.327	45.557	2.156	39.073	21.577	0.466
4 t/ ha / Flag leaf blade	367.667	1225.333	7.487	20.353	58.767	2.409	51.333	18.313	0.485
8 t/ ha / Awn	491.333	1270.000	6.023	18.103	48.707	1.916	39.693	21.043	0.451
12 t/ha / both	452.333	1306.667	6.360	19.227	55.117	2.317	48.333	20.933	0.463
0 t/ ha Control	479.000	1476.333	6.633	18.873	50.947	2.260	44.863	21.894	0.480
4 t/ ha / Flag leaf blade	475.000	1289.000	5.150	15.053	40.830	1.715	38.433	19.185	0.430
8 t/ ha / Awn	435.333	1095.667	5.107	14.730	38.863	1.827	38.533	19.321	0.412
12 t/ha / both	462.667	1381.667	7.187	21.000	52.163	2.327	50.697	22.155	0.485
0 t/ ha Control	429.000	1266.333	6.367	18.343	51.187	2.151	49.093	20.235	0.458
4 t/ ha / Flag leaf blade	486.333	1060.333	5.150	15.380	43.577	1.487	38.870	19.943	0.367
8 t/ ha / Awn	455.333	1069.667	5.467	13.847	45.007	1.740	39.707	20.515	0.379
12 t/ha / both	470.000	1304.667	6.093	17.277	51.040	2.412	44.533	21.809	0.501
2013-2014 Season									
0 t/ ha Control	390.667	1323.000	6.433	18.200	50.600	2.243	50.167	20.857	0.468
4 t/ ha / Flag leaf blade	381.333	1028.000	5.900	18.100	53.333	2.163	46.533	18.363	0.430
8 t/ ha / Awn	465.333	1090.000	6.100	18.967	56.900	2.703	47.767	18.133	0.470
12 t/ha / both	485.333	1312.000	6.533	18.333	53.667	2.360	48.667	19.417	0.501
0 t/ ha Control	485.333	1416.333	6.267	18.100	54.067	2.683	45.317	21.903	0.468
4 t/ ha / Flag leaf blade	371.000	1179.333	5.833	16.700	45.833	1.877	48.600	16.393	0.499
8 t/ ha / Awn	506.667	1287.667	5.867	17.500	48.467	2.123	44.683	21.267	0.456
12 t/ha / both	461.000	1317.333	6.433	18.300	54.567	2.323	50.050	20.023	0.482
0 t/ ha Control	482.667	1473.333	6.200	18.367	50.133	2.223	46.617	19.030	0.531
4 t/ ha / Flag leaf blade	460.000	1252.333	6.267	18.433	49.667	2.147	46.117	18.267	0.449
8 t/ ha / Awn	465.333	1169.333	6.300	18.100	48.867	2.397	46.353	19.067	0.441

12 t/ha / both	495.333	1466.000	6.400	18.600	46.433	1.800	48.450	21.647	0.481
0 t/ ha Control	448.000	1322.000	6.400	18.500	51.433	1.857	50.300	19.843	0.464
4 t/ ha / Flag leaf blade	473.333	1140.667	6.033	18.367	49.567	1.793	44.317	19.430	0.376
8 t/ ha / Awn	470.000	1107.000	6.133	17.700	50.467	1.930	46.120	20.500	0.380
12 t/ha / both	498.667	1362.333	6.667	18.667	55.667	2.540	48.507	19.637	0.518

Table 2: Correlation coefficient among studied characters at season 2012-2013

Characters	No. of spikes/ m²	Spike weight (g/m²)	Spike length (cm)	No. of spikelets/s spike	No. of grains/ spike	Grain weight /spike (g)	1000-grain weight (g)	Bio. yield (t/ha)	Harvest index
Spike weight (g/m²)	0.334								
Spike length (cm)	-0.646**	0.185							
No. of spikelets/spike	-0.459	0.369	0.910**						
No. of grains/spike	-0.499*	0.321	0.880**	0.917**					
Grain weight/spike (g)	-0.459	0.560*	0.739**	0.764**	0.806**				
1000-grain weight (g)	-0.537*	0.255	0.851**	0.924**	0.915**	0.728**			
Biological yield (t/ha)	0.349	0.597*	0.224	0.432	0.403	0.461	0.392		
Harvest index	-0.036	0.765**	0.369	0.400	0.415	0.752**	0.280	0.251	
Grain yield (t/ha)	0.156	0.849**	0.386	0.531*	0.527*	0.799**	0.435	0.749**	0.822**

**. Correlation is significant at the 0.05 level (2-tailed) ,* $t_{0.05}(14)=2.145$

***. Correlation is significant at the 0.01 level (2-tailed) ,* $t_{0.01}(14)=2.977$

Table 3: Correlation coefficient among studied characters at season 2013-2014

Characters	No. of spikes/ m²	Spike weight (g/m²)	Spike length (cm)	No. of spikelets/ spike	No. of grains/ Spike	Grain weight/ spike (g)	1000-grain weight (g)	Bio. yield (t/ha)	Harve st index
Spike weight (g/m²)	0.458								
Spike length (cm)	0.363	0.571*							
No. of spikelets/spike	0.430	0.225	0.606*						
No. of grains/spike	0.164	-0.090	0.381	0.571*					
Grain weight/spike (g)	0.220	0.082	0.316	0.360	0.752**				

1000-grain weight (g)	-0.337	0.268	0.559*	0.178	0.189	0.010			
Biological yield (t/ha)	0.533*	0.532*	0.363	0.219	0.035	0.046	-0.079		
Harvest index	0.077	0.655**	0.403	0.108	0.159	0.377	0.518*	-0.115	
Grain yield (t/ha)	0.478	0.893**	0.583*	0.280	0.177	0.352	0.348	0.589*	0.731**

**. Correlation is significant at the 0.05 level (2-tailed) ,* $t_{0.05}(14)=2.145$

***. Correlation is significant at the 0.01 level (2-tailed) ,* $t_{0.01}(14)=2.977$

Table 4: Path coefficient analysis among studied characters at season 2012-2013

Characters	No. of spikes/m²	Spike weight (g/m²)	Spike length (cm)	No. of spikelets /spike	No. of grains/ spike	Grain weight/ spike (g)	1000-grain weight (g)	Bio. yield (t/ha)	Harvest index
No. of spikes/m²	**0.356**	0.119	-0.230	-0.163	-0.177	-0.163	-0.191	0.124	-0.013
Spike weight (g/m²)	-0.015	**-0.044**	-0.008	-0.016	-0.014	-0.024	-0.011	-0.026	-0.033
Spike length (cm)	-0.016	0.005	**0.025**	0.023	0.022	0.018	0.021	0.006	0.009
No. of spikelets/spike	-0.007	0.005	0.013	**0.014**	0.013	0.011	0.013	0.006	0.006
No. of grains/spike	0.079	-0.051	-0.139	-0.145	**-0.158**	-0.127	-0.144	-0.064	-0.066
Grain weight/spike (g)	-0.293	0.358	0.472	0.488	0.515	**0.639**	0.465	0.295	0.480
1000-grain weight (g)	-0.038	0.018	0.060	0.066	0.065	0.052	**0.071**	0.028	0.020
Biological yield (t/ha)	0.103	0.175	0.066	0.127	0.118	0.135	0.115	**0.293**	0.074
Harvest index	-0.012	0.264	0.127	0.138	0.143	0.259	0.096	0.086	**0.345**
Grain yield ***Correlation***	***0.156***	***0.849***	***0.386***	***0.531***	***0.527***	***0.799***	***0.435***	***0.749***	***0.822***

Table 5: Path coefficient analysis among studied characters at season 2013-2014

Characters	No. of spikes/m²	Spike weight (g/m²)	Spike length (cm)	No. of spikelets /spike	No. of grains/ spike	Grain weight/ spike (g)	1000-grain weight (g)	Bio. yield (t/ha)	Harvest index
No. of spikes/m²	**0.078**	0.036	0.028	0.033	0.013	0.017	-0.026	0.041	0.006
Spike weight (g/m²)	-0.014	**-0.030**	-0.017	-0.007	0.003	-0.002	-0.008	-0.016	-0.020
Spike length (cm)	-0.012	-0.019	**-0.033**	-0.020	-0.013	-0.010	-0.018	-0.012	-0.013
No. of spikelets/spike	0.017	0.009	0.024	**0.039**	0.022	0.014	0.007	0.008	0.004

No. of grains/spike	0.000	0.000	-0.001	-0.001	**-0.001**	-0.001	0.000	0.000	0.000
Grain weight/spike (g)	-0.001	0.000	-0.002	-0.002	-0.004	**-0.006**	0.000	0.000	-0.002
1000-grain weight (g)	-0.007	0.005	0.011	0.004	0.004	0.000	**0.020**	-0.002	0.010
Biological yield (t/ha)	0.354	0.354	0.241	0.145	0.023	0.030	-0.052	**0.664**	-0.077
Harvest index	0.063	0.538	0.331	0.088	0.131	0.310	0.426	-0.095	**0.822**
Grain yield ***Correlation***	***0.478***	***0.893***	***0.583***	***0.280***	***0.177***	***0.352***	***0.348***	***0.589***	***0.731***

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