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(Original Article)

Path Coefficient Analysis for Grain Yield and Some of its Attributes in Bread wheat (*Triticum aestivum* L.).

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Abstract

Path coefficient analyses were applied to detect the direct and indirect effects upon grain yield/plant in three groups as a: each of seed index, biological yield/plant and weight of spikes/plant; b: each of thrashing index, biological yield/plant and weight of spikes/plant; and c: all studied grain yield attributes. The three groups of path analyses were applied through F_4 and F_5 population of The direct effects of biological yield and .early and late pedigree line selection weight of spikes spikes/plant were decreased from the starting generations to final selections in the three groups, except final early selections possessed increased values in group two (g2) and group three (g3) for weight of spikes/plant. Otherwise, the direct effect of harvest index on grain yield was increased from started base to final selections. These results exhibited that the direct effects of those three traits on grain yield were responded differently according to the rearrangement of their genetic make-up across the different generations of selections and the type of path analysis.

Keywords: *Path analysis, direct and indirect effects, bread wheat.*

Introduction

Wheat is the main food and the most strategic cereal crop in Egypt. Wheat grains are used as food for humans, and the straw is used as fodder for animals. Its area amounted to about 1.33 million hectares (3.17 million faddan) in 2019/2020 growing season producing a total of 8.5 million tons of grains with an average of 6.4 tons/ha-^{1} (17.85 Ardab faddan-^{1}) (Economic Affairs Annual Report, 2020).

Path coefficient analysis considered one of the most important statistical tools which can help breeders to characterize the crop populations during the selection program and select the desirable genotypes of high yield. Path coefficient analysis and correlation values present a better understanding of the relationship for different attributes with grain yield. Correlation is benefit to determine the direction of the relationship among yield and its various attributes. Meanwhile, path coefficient or partial regression coefficient accounted the

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contributions as direct effect of the predictor variable as well as its indirect effect(s) across other attributes including in path analysis (Dewey and Lu, 1959).

Correlation study between different characters may help the plant breeder to know how the improvement of one character will bring simultaneous changes in other characters (Sabit *et al*., 2017 and Kadan *et al*., 2022). The information on the nature and magnitude of correlation coefficients helps breeders to determine the selection criteria for simultaneous improvement of various characters along with yield. Determination of correlation coefficients between various wheat characters helps to obtain best combinations of attributes for obtaining higher return per unit area. Moreover, correlation studies along with path analysis provide a better understanding of the association of different characters with grain yield. Path coefficient analysis used to determine the direct and indirect effects on target trait through other related characters by partitioning the correlation coefficient into both effects (Dixet and Dubey, 1984; Milkessa, 2022 and Stojsin *et al*., 2022). The objective of the current study was to assess direct and indirect effects of highest correlated traits on grain yield through path coefficient analysis across the successive generations.

Material and Methods

The present study was carried out during the three successive seasons i.e., 2019/2020, 2020/2021 and 2021/2022 at Agronomy farm, Faculty of Agriculture, Assiut University, Egypt in order to estimate the phenotypic correlation as well as path coefficient analyses for wheat yield and its contributing characters. The started breeding materials used in this study were 500 F3- families traced back to random F2- plants from the cross: (Misr 2 × Sakha 94).

Statistical analysis

The phenotypic (r_{pij}) correlations

The phenotypic (rpij) correlation coefficients were calculated between each a pair of the studied traits as outlined by Walker (1960). using the following formula:-

$$rp_{ij} = Cov.\ p_{ij} / \sigma^2_{pi}\ x\ \sigma^2_{pj}$$

Where;

Cov. pij: the phenotypic covariance between i and j traits,

σ2pi and σ2pj are the phenotypic standard deviation of the trait i and j, respectively.

Path coefficient analysis

Path coefficient analysis was done according to the procedure followed by Dewey and Lu (1959). The contributions of biological yield/plant (BYP), number of spikes/plant (NSP), harvest index (HI) and seed index (SI), who possessed positive and high correlation values with grain yield/plant (GYP), especially the former two traits, as well as residual factors (X) were included in the path coefficient analysis in the F3 base population as the following Fig. 1

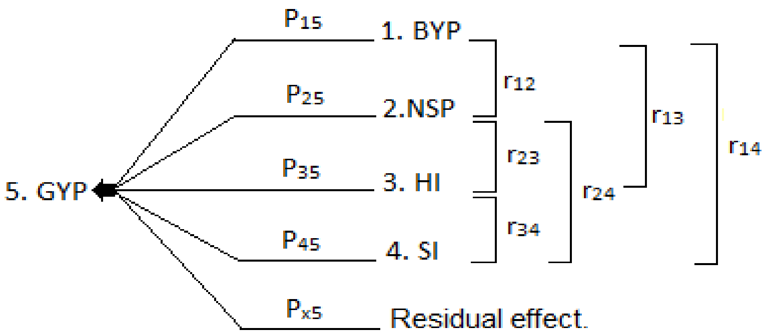

Fig. 1. Direct and indirect effects of BYP , NSP , Hl and Slon GYP in F3 base population

r15= p15 + r12 p25 + r13 p35 + r14 p45
r25= p25 + r12 p15 + r23 p35 + r24 p45
r35= p35 + r13 p15 + r23 p25 + r34 p45
r45= p45 + r14 p15 + r24 p25 + r34 p35

1 = P2xy + P215 + P225 + P235+ P245 + 2P15r12P25 + 2P15r13P35 + 2P15r14p45 + 2P25r23P35 + 2P25r24P45 + 2P35r34P45

Moreover, path analysis was done including all 500 families and selections through the F4 and F5 generations in three patterns i.e. group 1 (g1) included seed index (SI), biological yield/plant (BYP), weight of spikes/plant (SWP) and grain yield/plant (GYP); group 2 (g2) possessed thrashing index (TI) instead of seed index in g1 (Fig. 2); and group 3 (g3) had the ten studied traits (Fig. 3) as presenting below:

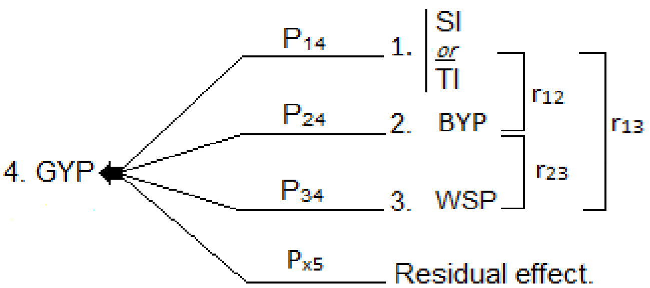

Fig.2. Direct and indirect effects of Sl or, BYP and WSP on GYP in all families and selections in F4 and F5 generations

$$r_{14} = p_{14} + r_{12}\, p_{24} + r_{13}\, p_{34}$$

$$r_{24} = p_{24} + r_{12}\, p_{14} + r_{23}\, p_{34}$$

$$r_{34} = p_{34} + r_{13}\, p_{14} + r_{23}\, p_{24}$$

$$1 = p_{xy}^2 + p_{14}^2 + p_{24}^2 + p_{34}^2 + 2p_{14}r_{12}p_{24} + 2p_{14}r_{13}p_{34} + 2p_{24}r_{23}p_{34}$$

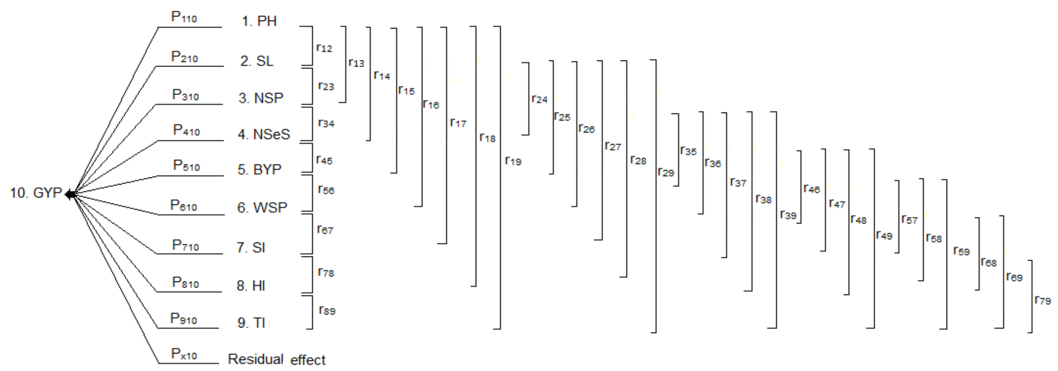

Fig.3. Direct and indirect effects of PH, SL, NSP, NSeS, BYP, Sl Hl and Tl on GYP for all families and selections in F4 and F5 generations

r110 = p110+r12p210+r13p310+r14p410+r15p510+r16p610+r17p710+r18p810+r19p910
r210 = p210+r12p110+r23p310+r24p410+r25p510+r26p610+r27p710+r28p810+r29p910
r310 = p310+r13p110+r23p210+r34p410+r35p510+r36p610+r37p710+r38p810+r39p910
r410 = p410+r14p110+r24p210+r34p310+r45p510+r46p610+r47p710+r48p810+r49p910
r510 = p510+r15p110+r25p210+r35p310+r45p410+r56p610+r57p710+r58p810+r59p910
r610 = p610+r16p110+r26p210+r36p310+r46p410+r56p510+r67p710+r68p810+r69p910
r710 = p710+r17p110+r27p210+r37p310+r47p410+r57p510+r67p610+r78p810+r79p910
r810 = p810+r18p110+r28p210+r38p310+r48p410+r58p510+r68p610+r78p710+r89p910
r910 = p910+r19p110+r29p210+r39p310+r49p410+r59p510+r69p610+r79p710+r89p810
1= P2xy+P2110+P2210+P2310+P2410+P2510+P2610+P2710+P2810+P2910+2P110r12P210+ 2P110r13P310+2P110r14p410+2P110r15P510+2P110r16P610+2P110r17P710+2P110r18p810 +2P110r19P910+2P210r23P310+2P210r24p410+2P210r25P510+2P210r26P610+2P210r27P710+2P210r28p810+2P210r29P910+2P310r34p410+2P310r35P510+2P310r36P610+2P310r37P710+2P310r38p810+2P310r39P910+2P410r45P510+2P410r46P610+2P410r47P710+2P410r48p810+2P410r49P910+2P510r56P610+2P510r57P710+2P510r58p810+2P510r59P910+2P610r67P710+2P610r68p810+2P610r69P910+2P710r78p810+2P710r79P910+2P810r89P910.

Results and Discussion.

Phenotypic coefficients of correlation between each pair of traits in F_3 base population

The values of phenotypic correlations between grain yield/plant and each of biological yield/plant and number of spikes/plant were high and accounted 0.828 and 0.784, respectively. Moreover, high value of correlation (0.715) recorded between biological yield/plant and number of spikes/plant. Other traits i.e., harvest index and seed index were correlated phenotypically less of 0.277 with grain yield/plant. Otherwise, neglected or negative values of correlations were recorded between each pair of the other traits as shown in Table 1. The obtained results are in line with Abdel El-Kareem and El-Saidy (2011), Khan and Naqvi (2012); Vamshikrishna *et al*. (2013); Nasri *et al*. (2014) and Mostafa (2015).

Phenotypic correlation coefficients among studied traits

The coefficients of phenotypic correlation between each pair for studied traits of 500 families in F4 and F5, selected families in cycle one (50 F4 and F5 selected families), selected families in cycle two (early pedigree line selection

(10 F5 early selected families) as well as one cycle of late selection (10 F5 late selected families) for grain yield/plant are presented in Tables 2 and 3.

Grain yield/plant possessed positive and high phenotypic correlation with each of number of spikes/plant (0.784), biological yield/plant (0.828) in the F3 base population (Table 1) and weight of spikes/plant (0.949) in 500 F4 families (Table 2). These values of coefficient of correlation were reduced to 0.258, 0.677 and 0.726 after one cycle of pedigree line selection (50 F4 early selection, Table 3) and to -0.306, -0.008 and 0.561 after two cycles of pedigree line selection (10 F5 early selections, Table 4) as well as -0.139, 0.496 and 0.363 after one cycle of late selection (10 F5 late selections, Table 4) for number of spikes/plant, biological yield/plant and weight of spikes/plant, respectively. In spite of less values of correlation, same trend of correlations view recorded between grain yield/plant and each of plant height, spike length, number of spikelets/spike and seed index across the successive selection cycles. Otherwise, the coefficients of correlation between grain yield/plant and harvest index were increased from F3 base population (0.221) to 10 F5 early selections (0.385) as well as 10 F5 late selections (0.484). These results may be due to that the selected families responded differently to increase or decrease those correlated traits, although their high response to increase the grain yield/plant.

Moreover, biological yield/plant had the same scenario which was observed for grain yield/plant, where the coefficients of correlation between biological yield/plant with rest traits were decreased with the progression of selection cycles. These values of coefficient of correlation of biological yield/plant were reduced from 0.715, 0.339 and -0.319 in F3 base population (Table 1) to 0.538, -0.306 and -0.647 after one cycle of pedigree line selection (50 F4 early selection, Table 3) and to 0.268, 0.003 and -0.923 after two cycles of pedigree line selection (10 F5 early selections, Table 4) as well as 0.096, -0.467 and -0.518 after one cycle of late selection (10 F5 late selections) with number of spikes/plant, seed index and harvest index, respectively. In agreement with this context, biological yield/plant dropped in its correlation from 0.420, 0.573 and 0.921 in 500 F4 families to 0.254, 0.539 and 0.799 after on cycle of pedigree line selectin (50 F4 selections) and to 0.351, 0.293 and 0.619 after two cycles of pedigree line selection (10 F5 early selection) as well as 0.150, 0.111 and 0.623 with spike length, number of spikelets/spike and weight of spikes/plant, respectively. Same correlations trend viewed between biological yield/plant and each of plant height and thrashing which recorded 0.502 and 0.535 after one cycle of pedigree line selection (50 F4 selections) reduced to 0.0.316 and 0.286 after 10 F5 late selections, respectively (Tables 2 and 4).

Table 1. Correlation coefficients between each pair of main yield traits in F3 base population

Traits	Biological yield/plant, g	Number. of spikes/plant	Grain yield/plant, g	Harvest index, %	seed index, g
Biological yield/plant, g	-	0.715	0.828	-0.319	0.339
Number. of spikes/plant		-	0.784	0.050	0.162
Grain yield/plant, g			-	0.221	0.276
Harvest index, %				-	-0.136
seed index, g					-

Table 2. Phenotypic correlation coefficients for all studied traits of all 500 families in F4 (above diagonal) and F5 (below diagonal)

Traits	Plant height, cm	Spike length, cm	Number of spikes/ plants	Number of spikelets/ spikes	Biological yield/plant, g	Weight of spikes/ plant, g	Grain yield/ plant, g	Seed index, g	Harvest index	Thrashing index
Plant height, cm	-	0.163	0.163	0.164	0.234	0.109	0.075	-0.033	-0.260	0.063
Spike length, cm	0.133	-	-0.144	-0.148	0.420	0.404	0.321	0.105	-0.910	0.189
Number of spikes/plants	0.190	-0.295	-	0.962	0.603	0.551	0.529	-0.064	0.030	-0.033
Number of spikelets/ spikes	0.206	-0.271	0.962	-	0.573	0.507	0.477	-0.074	-0.027	-0.003
Biological yield/plant, g	0.059	0.277	0.252	0.237	-	0.921	0.870	0.250	0.036	-0.012
Weight of spikes/ plant, g	-0.016	0.271	0.199	0.166	0.918	-	0.949	0.372	0.323	-0.054
Grain yield/ plant, g	0.014	0.215	0.198	0.158	0.857	0.933	-	0.439	0.513	-0.352
Seed index, g	-0.073	0.123	-0.142	-0.154	0.262	0.315	0.293	-	0.452	-0.322
Harvest index	-0.052	-0.049	-0.031	-0.080	-0.014	0.262	0.497	0.144	-	-0.716
Thrashing index	-0.102	0.145	0.028	0.044	0.210	0.231	-0.123	0.060	-0.621	-

Moreover, weight of spikes/plant was correlated positively medium or less values ranged from 0.109 to 0.551 in 500 F4 families and reduced to negative or neglected values in 10 F5 early and late selected families with spike length, number of spikelets/spike, seed index and harvest index. Otherwise, weight of spikes/plant was associated with values of 0.404 and -0.054 across 500 F4 families and increased up to 0.426 and 0.747 after one cycle (50 F4 selections) and to 0.464 and 0.769 after two cycles of early pedigree line selection (10 F5 early selection) as well as 0.663 and 0.772 after one cycle of late selection (10 F5 late selection with spike length and thrashing index, respectively (Tables 2 and 4).

Concerning to the correlation of number of spikes/plant with the rest traits, of the same trend has been observed with weight of spikes/plant and the values of correlation reduced from the F3 base population or 500 F4 families to early (10 F5 early selections) and late selection (10 F5 late selections) for spike length, seed index, harvest index and thrashing index. In contrast, correlation coefficients of number of spikes/plant with plant height and number of spikelets/spike were increased from 0.163 and 0.962 in 500 F4 families to 0.580 and 0.982 after one cycle (50 F4 selection (Table 3) and to 0.714 and 0.977 after two cycles of pedigree line selection (10 F5 early selection) as well as 0.682 and 0.995 of one cycle of late selection (10 F5 late selections), respectively.

Others values of correlations coefficients among rest of studied characters were neglected values.

It is remarkable results that the presented values of correlation had decreased or increased across the cycles of selection. These results could be expressed as change in genetic make-up of gene/s controlled the studied characters across selection generations.

The obtained results revealed that the most effective yield components in grain yield of wheat would be both of number and weight of spikes/plant as well as biological yield as major issues, whereas spike length and number of spikelets/spike have minor effects. It is concluded that these traits can be used for grain yield improvement of wheat.

The values of positive correlation were recorded between grain yield and each of number of spikes. Fouad (2018), Rathod *et al*., (2019), Upadhyay (2020) and Milkessa (2022)), biological yield/plant Shamuyarira *et al*., (2019), AL-Najjar and Al-Zubaidy (2020), Baye *et al*., (2020), Semnaninejad *et al*., (2021) and Milkessa (2022)). In addition, the obtained values of correlations are in line with those obtained by Saleh (2017), Barman *et al*., (2020), Haydar (2020), Kadan *et al*., (2022), Mahdy Rasha *et al*., (2022) and Stojsin *et al*., (2022).

Table 3. Phenotypic correlation coefficients for all studied traits of 50-selected families in F4 (above diagonal) and F5 (below diagonal)

Traits	Plant height, cm	Spike length, cm	Number of spikes/ plants	Number of spikelets/ spikes	Biological yield/plant, g	Weight of spikes/ plant, g	Grain yield/ plant, g	Seed index, g	Harvest index	Thrashing index
Plant height, cm	-	-0.077	0.580	0.603	0.502	0.21	0.074	-0.496	-0.591	0.217
Spike length, cm	-0.140	-	-0.516	-0.507	0.254	0.426	0.208	0.382	-0.106	0.432
Number of spikes/plants	0.513	-0.551	-	0.982	0.538	0.268	0.258	-0.549	-0.474	0.141
Number of spikelets/ spikes	0.517	-0.527	0.985	-	0.539	0.253	0.212	-0.525	-0.520	0.157
Biological yield/plant, g	-0.084	0.358	0.134	0.136	-	0.799	0.677	-0.306	-0.647	0.535
Weight of spikes/ plant, g	-0.211	0.423	-0.089	-0.118	0.896	-	0.726	0.030	-0.299	0.747
Grain yield/ plant, g	-0.068	0.304	-0.006	-0.049	0.755	0.878	-	0.061	0.117	0.104
Seed index, g	-0.604	0.360	-0.502	-0.513	0.248	0.361	0.244	-	0.461	-0.005
Harvest index	0.092	-0.071	-0.158	-0.221	-0.313	-0.009	0.378	-0.024	-	-0.583
Thrashing index	-0.381	0.323	-0.176	-0.163	0.508	0.503	0.039	0.353	-0.700	-

Table 4. Phenotypic correlation coefficients for all studied traits of 10-selected families in F5 (early above diagonal) and (late below diagonal)

Traits	Plant height, cm	Spike length, cm	Number of spikes/ plant	Number of spikelets/ spikes	Biological yield/plant, g	Weight of spikes/ plant, g	Grain yield/ plant, g	Seed index, g	Harvest index	Thrashing index
Plant height, cm	-	-0.127	0.714	0.750	0.218	-0.292	-0.615	-0.679	-0.433	0.098
Spike length, cm	-0.338	-	-0.639	-0.597	0.351	0.464	-0.100	0.414	-0.361	0.640
Number of spikes/plant	0.682	-0.603	-	0.997	0.268	-0.344	-0.306	-0.628	-0.377	-0.165
Number of spikelets/ spikes	0.705	-0.635	0.995	-	0.293	-0.342	-0.362	-0.624	-0.420	-0.121
Biological yield/plant, g	0.316	0.150	0.096	0.111	-	0.619	-0.008	0.003	-0.923	0.792
Weight of spikes/ plant, g	0.099	0.663	-0.426	-0.423	0.623	-	0.561	0.280	-0.34	0.769
Grain yield/ plant, g	-0.114	-0.060	-0.139	-0.082	0.496	0.363	-	0.110	0.385	-0.093
Seed index, g	-0.711	0.628	-0.511	-0.558	-0.467	-0.115	-0.374	-	0.043	0.275
Harvest index	-0.458	-0.205	-0.234	-0.196	-0.518	-0.266	0.484	0.109	-	-0.745
Thrashing index	0.134	0.738	-0.403	-0.438	0.286	0.772	-0.307	0.174	-0.588	-

Path analysis for grain yield/plant in the F_3 base population.

The partitioning of phenotypic correlation into direct and indirect effects by path analysis revealed that the highest value of direct effect on grain yield/plant was achieved by biological yield/plant (0.9062) followed by harvest index (0.5075) in the F3 base population. Additionally, the highest indirect effects were correlated also with the biological yield/plant across number of spikes/plant (0.6479) and seed index (0.3072) in the F3 base population. These results provided that the biological yield/plant has exhibited to be powerful trait as a yield component and must be given preference in selection to superior genotypes of wheat (Table 5). Otherwise, the rest studied traits exerted less or neglected direct and effects for grain yield/plant in the F3 base population.

It is remark and clear conclusion that the path coefficient analysis revealed that the residual effect of unstudied traits was low and accounted 0.2184 in grain yield/plant.

Table 5. Partitioning of phenotypic correlation into direct and indirect effects by path coefficient analysis for F3 base population

1- Biological yield/plant vs grain yield/plant		**r =**	**0.8280**
Direct effect,	P15	=	0.9062
Indirect effects via number of spikes/plant,	r12 p25	=	0.0768
Indirect effects via harvest index,	r13 p35	=	-0.1619
Indirect effects via seed index,	r14 p45	=	0.0069
	Total	**=**	**0.8280**
2- Number of spikes/plant vs grain yield/plant		**r =**	**0.7840**
Direct effect,	P25	=	0.1074
Indirect effects via biological yield/plant,	r12 p15	=	0.647902
Indirect effects via harvest index,	r23 p35	=	0.025374
Indirect effects via seed index,	r24 p45	=	0.003309
	Total	**=**	**0.7840**
3- Harvest index vs grain yield/plant		**r =**	**0.2210**
Direct effect,	P35	=	0.5075
Indirect effects via biological yield/plant,	r13 p15	=	-0.28906
Indirect effects via number of spikes/plant,	r23 p25	=	0.005371
Indirect effects via seed index,	r34 p45	=	-0.00278
	Total	**=**	**0.2210**
4- Seed index vs grain yield/plant		**r =**	**0.2760**
Direct effect,	P45	=	0.0204
Indirect effects via biological yield/plant,	r14 p15	=	0.307187
Indirect effects via number of spikes/plant,	r24 p25	=	0.017401
Indirect effects via harvest index,	r34 p35	=	-0.06902
	Total	**=**	**0.2760**
5- Res. effect		**X =**	**0.2184**

Path coefficient analysis in the F_4 and F_5 generations of all families, one cycle (50 F_4 selections) and two cycles (10 F_5 early selections) of early pedigree line selection as well as one cycle of late selection (10 F_5 late selections) for grain yield/plant.

The coefficients of phenotypic correlation were estimated between each pairs of studied traits in F_4 and F_5 of all families, one cycle (50 F_4 selections) and two cycles (10 F_5 early selections) of early pedigree line selection as well as one cycle of late selection (10 F_5 late selections) (Tables 2 and 4).

High and positive estimates of correlation coefficients were recorded between grain yield/plant and each of biological yield/plant and weight of spikes/plant in F_4 and F_5 of all families, one cycle of pedigree line selection (50 F_4 selections) in range of 0.677~ 0.949. These values of correlation were reduced after two cycles (10 F_5 early selections) of early pedigree line selection as well as one cycle of late selection (10 F_5 late selections) in range of -0.008~ 0.561.

The inferenced phenotypic associations, if used in detail issues become more complicated for understanding. In order to find a better solve of such problem, the breeders may apply path coefficient analysis, where direct effect of one variable upon another could be estimated and coefficients of correlation are easily partitioned into two components i.e., direct and indirect effects (Chaudhary, 1995).

The obtained coefficients of phenotypic correlation were partitioned using path analysis into direct and indirect effects upon grain yield/plant in three groups as *a:* each of seed index, biological yield/plant and weight of spikes/plant; *b:* each of thrashing index, biological yield/plant and weight of spikes/plant; and *c:* all attributes of grain yield. The three groups of path analysis were applied through F_4 and F_5 of all families, one cycle (50 F_4 selections) with its F_5 and two cycles of early pedigree line selection (10 F_5 early selections) as well as one cycle of late selection (10 F_5 late selections).

The partitioning of correlation coefficients into direct and indirect effects by path analysis resulted that the highest direct effects on grain yield/plant were obtained by biological yield/plant and harvest index with values of 0.9062 and 0.5075 in F_3 base population, which increase in group *c* of path analysis to 1.4354 and 0.9731 after one cycle (50 F_4 selections) and recorded 0.7073 and 0.9901 after two cycles of pedigree line selection (10 F_5 early selection), as well as to 0.6993 and 0.6427 after one cycle of late selection (10 F_5 late selections). Moreover, weight of spikes/plant exerted direct effect on grain yield/plant of 0.8874, 0.8773 and 0.8852 across 500 F_4 families in g1, g2 and g3 of path analysis, respectively. The value of direct effect in g2 was increased to 1.2546 in cycle one (50 F_4 selections) and be more increase values of 1.3706 and 2.6666 in cycle two (10 F_5 early selections) of pedigree selection and one cycle of late selection (10 F_5 late selections), respectively. Concerning to g1 and g3 of path analysis, the direct effects of weight of spikes/plant on grain yield/plant were decreased to 0.4771 and -0.1472 after one cycle of pedigree line selection (50 F_4

selections) and to 0.2460 and 0.5176 in late selection (10 F_5 late selections), respectively. It was appeared different result in cycle two of pedigree line selection (10 F_5 selections), g1 and 3 increased to 0.7875 and 0.9302, respectively (Tables 6 and 8).

In general conclusion, the direct effects for both biological yield and weight of spikes/plant were decreased from the starting generations i.e., F_3 base or F_4 families to F_5 selections in the three groups, except F_5 early selections possessed increased values in g2 and g3 for weight of spikes/plant. Otherwise, the direct effect of harvest index on grain yield was increased from F_3 base to F_5 selections. These results exhibited that the direct effects of those three traits on grain yield were responded differently according to the rearrangement of their genetic make-up across the different generations of selections and the type of path analysis including different traits.

Furthermore, the highest indirect effects on grain yield/plant were obtained also with the biological yield/plant in F_3 base population and biological yield/plant and weight of spikes/plant through the two cycles (F_4 and F_5) of pedigree line selection and one cycle (F_5) of late selections. Mostly, the measures of these indirect effects were larger via number of spikes/plant than biological yield/plant across F_4 and F_5 selections. In addition to, these indirect effects were decreased gradually in most cases from the starting generations to the last cycle of selection. Moreover, the values of these indirect effects were different according to the yield attributes including in the group of path analysis.

The remarkable values of the indirect effect for spikes weight of spikes/plant on grain yield/plant were 0.2840 and 0.7772 in 500 F_4 families and decreased to 0.1796 and 0.5174 in 10 F_5 early selections and to -0.0239 and 0.1736 in 10 F_5 late selections through seed index and biological/plant of group *a* of path analysis, respectively (Table 6). Same context could be found for indirect effects of weight of spikes/plant on grain yield/plant as accounted 0.0965, 0.4877, 0.4488, 0.8152, 0.3293 and 0.2859 in 500 F_4 families and decreased to 0.2716, -0.3200, -0.3181, 0.5758, 0.2605 and -0.3163 in 10 F_5 early selection and 0.0512, -0.2205, -0.2189, 0.3224, -0.0595 and -0.1377 in 10 F_5 late selections via plant height, number of spikes/plant, number of spikelets/spike, biological yield/plant, seed index and harvest index for group c of path analysis, respectively (Table 8). Otherwise, the indirect effect of weight of spikes/plant onto grain yield/plant were -0.0474 and 0.7686 in 500 F_4 families and increased to 1.0546 and 0.9005 in 10 F_5 early selections and to 2.0586 and 1.8826 in 10 F_5 late selections through thrashing index and biological/plant of group *b* of path analysis, respectively (Table 7). Same trend of increased indirect effect of weight of spikes/plant onto grain yield/plant were 0.3576 and -0.0478 in 500 F_4 families and increased to 0.4316 and 0.7153 in 10 F_5 early selections and to 0.3431 and 0.3996 in 10 F_5 late selections through spike length and thrashing index of group *c* of path analysis, respectively (Table 8).

Table 6. Partitioning of path analysis for grain yield/plant across group a of attributes for all 500 families and selections across two cycles (F4 and F5) of pedigree selection.

		All families		50 selections		10 selections	
		F4	**F5**	**F4**	**F5**	**F5 early**	**F5 Late**
1- Seed Index	r =	**0.3670**	**0.2360**	**0.1360**	**0.2070**	**0.1030**	**-0.2190**
Direct effect,	P14 =	0.0817	0.0027	0.1124	-0.0755	-0.0757	-0.1119
Indirect effects via biological yield/plant,	r12 p24 =	0.0013	-0.0049	-0.0327	-0.0396	-0.0008	-0.0832
Indirect effects via spikes weight/plant ,	r13 p34 =	0.2840	0.2382	0.0563	0.3221	0.1796	-0.0239
Total	=	**0.3670**	**0.2360**	**0.1360**	**0.2070**	**0.1030**	**-0.2190**
2-Biolodical yield/plant	r =	**0.8010**	**0.8030**	**0.5770**	**0.6820**	**0.1120**	**0.5090**
Direct effect,	P24 =	0.0063	-0.0217	0.2285	-0.1888	-0.4052	0.3048
Indirect effects via seed index ,	r12 p14 =	0.0174	0.0006	-0.0161	-0.0159	-0.0002	0.0306
Indirect effects via spikes weight/plant ,	r23 p34 =	0.7773	0.8241	0.3645	0.8866	0.5174	0.1736
Total	=	**0.8010**	**0.8030**	**0.5770**	**0.6820**	**0.1120**	**0.5090**
3- Spikes weight/plant	r =	**0.9190**	**0.9010**	**0.6650**	**0.8200**	**0.5040**	**0.4720**
Direct effect,	P34 =	0.8874	0.9197	0.4771	1.0098	0.7875	0.2460
Indirect effects via seed index,	r13 p14 =	0.0261	0.0007	0.0133	-0.0241	-0.0173	0.0109
Indirect effects via biological yield/plant,	r23 p24 =	0.0055	-0.0194	0.1746	-0.1657	-0.2662	0.2152
Total =		**0.9190**	**0.9010**	**0.6650**	**0.8200**	**0.5040**	**0.4720**
4- Res. Effect		**0.3867**	**0.4337**	**0.7318**	**0.5624**	**0.8101**	**0.8392**

Table 7. Partitioning of path analysis for grain yield/plant across group b of attributes for all 500 families and selections across two cycles (F4 and F5) of pedigree selection

		All families		50 selections		10 selections	
		F4	**F5**	**F4**	**F5**	**F5 Early**	**F5 Late**
1- Thrashing Index	r =	**-0.3520**	**-0.1260**	**0.1040**	**0.0390**	**-0.0930**	**-0.3070**
Direct effect,	P14 =	-0.3043	-0.3529	-0.8813	-0.4980	-1.4018	-2.1485
Indirect effects via biological yield/plant,	r12 p24=	-0.0003	-0.0034	0.0482	-0.0109	0.2548	-0.2171
Indirect effects via spikes weight/plant ,	r13 p34 =	-0.0474	0.2304	0.9372	0.5479	1.0540	2.0586
Total	=	**-0.3520**	**-0.1260**	**0.1040**	**0.0390**	**-0.0930**	**-0.3070**
2-Biolodical yield/plant	r =	**0.8010**	**0.8030**	**0.5770**	**0.6820**	**0.1120**	**0.5090**
Direct effect,	P24 =	0.0288	-0.0164	0.0900	-0.0214	0.3218	-0.7591
Indirect effects via thrashing index ,	r12 p14 =	0.0037	-0.0741	-0.4715	-0.2530	-1.1103	-0.6145
Indirect effects via spikes weight /plant,	r23 p34 =	0.7686	0.8935	0.9585	0.9564	0.9005	1.8826
Total	=	**0.8010**	**0.8030**	**0.5770**	**0.6820**	**0.1120**	**0.5090**
3- Spikes weight/plant	r =	**0.9190**	**0.9010**	**0.6650**	**0.8200**	**0.5040**	**0.4720**
Direct effect,	P34 =	0.8773	0.9972	1.2546	1.0893	1.3706	2.6666
Indirect effects via thrashing index,	r13 p14 =	0.0164	-0.0815	-0.6584	-0.2505	-1.0780	-1.6586
Indirect effects via biological yield/plant,	r23 p24 =	0.0252	-0.0147	0.0688	-0.0188	0.2114	-0.5360
Total	=	**0.9190**	**0.9010**	**0.6650**	**0.8200**	**0.5040**	**0.4720**
4- Res. Effect		**0.2521**	**0.2650**	**0.4532**	**0.3752**	**0.3779**	**Neglected**

Table 8. Partitioning of path analysis for grain yield/plant across group *c* of yield attributes for all 500 families and selection across two cycles (F4 and F5) of pedigree selection

		All families		50 Selections		10 Selections	
		F4	F5	F4	F5	F5	F5
1- Plant height (PH),	r =	0.0750	0.0140	0.0740	-0.0680	-0.6150	-0.1140
Direct effect	P1 =	-0.0159	-0.0068	-0.0229	-0.0449	-0.3623	0.2236
Indirect effect via spike length (LS),	r12P2 =	-0.0013	-0.0004	0.0013	0.0010	-0.0471	-0.0042
Indirect effect via number of spikes/plant (NSP),	r13P3 =	0.0048	0.0023	0.1063	0.0207	0.6729	0.2926
Indirect effect via number of spikelets/spike (NSeS),	r14P4 =	-0.0057	-0.0027	-0.0976	-0.0178	-0.3040	-0.4649
Indirect effect via biological yield/plant (BYP),	r15P5 =	0.0142	0.0256	0.7205	-0.0465	0.1542	0.2190
Indirect effect via weight of spikes/plant (WSP),	r16P6 =	0.0965	-0.0081	-0.0309	-0.1029	-0.2716	0.0512
Indirect effect via seed index (SI),	r17P7 =	0.0000	0.0007	-0.0331	0.0041	0.0412	-0.0442
Indirect effect via harvest index (HI),	r18P8 =	0.0015	-0.0138	-0.5751	0.0377	-0.4287	-0.2944
Indirect effect via thrashing index (TI),	r19P9 =	-0.0192	0.0173	0.0055	0.0806	-0.0696	-0.0928
	Total =	0.0750	0.0140	0.0740	-0.0680	-0.6150	-0.1140
2- Spike length (SL),	r =	0.3210	0.2150	0.2080	0.3040	-0.1000	-0.0600
Direct effect,	P2 =	-0.0078	-0.0031	-0.0164	-0.0072	0.3711	0.0123
Indirect effect via plant height (PH),	r12P1 =	-0.0026	-0.0009	0.0018	0.0063	0.0460	-0.0756
Indirect effect via number of spikes/plant (NSP),	r23P3 =	-0.0043	-0.0036	-0.0946	-0.0222	-0.6022	-0.2587
Indirect effect via number of spikelets/spike (NSeS),	r24P4 =	0.0051	0.0036	0.0820	0.0181	0.2420	0.4187
Indirect effect via biological yield/plant (BYP),	r25P5 =	0.0255	0.1201	0.3646	0.1982	0.2482	0.1040
Indirect effect via weight of spikes/plant (WSP),	r26P6 =	0.3576	0.1376	-0.0627	0.2107	0.4316	0.3431
Indirect effect via seed index (SI),	r27P7 =	-0.0001	-0.0011	0.0255	-0.0024	-0.0251	0.0391
Indirect effect via harvest index (HI),	r28P8 =	0.0051	-0.0130	-0.1031	-0.0291	-0.3574	-0.1318
Indirect effect via thrashing index (TI),	r29P9 =	-0.0576	-0.0245	0.0109	-0.0683	-0.4542	-0.5112
	Total =	0.3210	0.2150	0.2080	0.3040	-0.1000	-0.0600
3- Number of spike/plant (NSP),	r =	0.5290	0.1980	0.2580	-0.0060	-0.3060	-0.1390
Direct effect,	P3 =	0.0296	0.0123	0.1833	0.0403	0.9424	0.4290
Indirect effect via plant height (PH),	r13P1 =	-0.0026	-0.0013	-0.0133	-0.0230	-0.2587	0.1525
Indirect effect via spike length (LS),	r23P2 =	0.0011	0.0009	0.0085	0.0040	-0.2372	-0.0074
Indirect effect via number of spikelets/spike (NSeS),	r34P4 =	-0.0334	-0.0126	-0.1589	-0.0339	-0.4041	-0.6561
Indirect effect via biological yield/plant (BYP),	r35P5 =	0.0366	0.1093	0.7722	0.0742	0.1895	0.0665
Indirect effect via weight of spikes/plant (WSP),	r36P6 =	0.4877	0.1011	-0.0394	-0.0434	-0.3200	-0.2205
Indirect effect via seed index (SI),	r37P7 =	0.0001	0.0013	-0.0366	0.0034	0.0381	-0.0318
Indirect effect via harvest index (HI),	r38P8 =	-0.0002	-0.0082	-0.4613	-0.0647	-0.3733	-0.1504
Indirect effect via thrashing index (TI),	r39P9 =	0.0101	-0.0047	0.0036	0.0372	0.1171	0.2792
	Total =	0.5290	0.1980	0.2580	-0.0060	-0.3060	-0.1390
4- Number of spikelets/spike (NSeS),	r =	0.4770	0.1580	0.2120	-0.0490	-0.3620	-0.0820
Direct effect,	P4 =	-0.0347	-0.0131	-0.1618	-0.0344	-0.4053	-0.6594
Indirect effect via plant height (PH),	r14P1 =	-0.0026	-0.0014	-0.0138	-0.0232	-0.2717	0.1576
Indirect effect via spike length (LS),	r24P2 =	0.0012	0.0008	0.0083	0.0038	-0.2216	-0.0078
Indirect effect via number of spikes/plant (NSP),	r34P3 =	0.0284	0.0118	0.1800	0.0397	0.9396	0.4269
Indirect effect via biological yield/plant (BYP),	r45P5 =	0.0348	0.1028	0.7737	0.0753	0.2072	0.0769
Indirect effect via weight of spikes/plant (WSP),	r46P6 =	0.4488	0.0843	-0.0372	-0.0575	-0.3181	-0.2189
Indirect effect via seed index (SI),	r47P7 =	0.0001	0.0014	-0.0350	0.0035	0.0379	-0.0347
Indirect effect via harvest index (HI),	r48P8 =	0.0002	-0.0212	-0.5060	-0.0906	-0.4159	-0.1260
Indirect effect via thrashing index (TI),	r49P9 =	0.0009	-0.0074	0.0040	0.0345	0.0859	0.3034
	Total =	0.4770	0.1580	0.2120	-0.0490	-0.3620	-0.0820
5- Biological yield/plant (BYP),	r =	0.8700	0.8570	0.6770	0.7550	-0.0080	0.4960
Direct effect,	P5 =	0.0608	0.4337	1.4354	0.5535	0.7073	0.6932
Indirect effect via plant height (PH),	r15P1 =	-0.0037	-0.0004	-0.0115	0.0038	-0.0790	0.0707
Indirect effect via spike length (LS),	r25P2 =	-0.0033	-0.0009	-0.0042	-0.0026	0.1303	0.0019
Indirect effect via number of spikes/plant (NSP),	r35P3 =	0.0178	0.0031	0.0986	0.0054	0.2526	0.0412
Indirect effect via number of spikelets/spike (NSeS),	r45P5 =	-0.0199	-0.0031	-0.0872	-0.0047	-0.1188	-0.0732
Indirect effect via weight of spikes/plant (WSP),	r56P6 =	0.8152	0.4662	-0.1176	0.4370	0.5758	0.3224
Indirect effect via seed index (SI),	r57P7 =	-0.0003	-0.0024	-0.0204	-0.0017	-0.0002	-0.0290
Indirect effect via harvest index (HI),	r58P8 =	-0.0002	-0.0037	-0.6296	-0.1283	-0.9139	-0.3329
direct effect via thrashing index (TI),	r59P9 =	0.0037	-0.0355	0.0135	-0.1075	-0.5621	-0.1981
Total	=	0.8700	0.8570	0.6770	0.7550	-0.0080	0.4960
6- Weight of spikes/plant (WSP),	r =	0.9490	0.9330	0.7260	0.8780	0.5610	0.3630
Direct effect,	P6 =	0.8852	0.5078	-0.1472	0.4877	0.9302	0.5176
Indirect effect via plant height (PH),	r16P1 =	-0.0017	0.0001	-0.0048	0.0095	0.1058	0.0221
Indirect effect via spike length (LS),	r26P2 =	-0.0032	-0.0008	-0.0070	-0.0031	0.1722	0.0082
Indirect effect via number of spikes/plant (NSP),	r36P3 =	0.0163	0.0024	0.0491	-0.0036	-0.3242	-0.1828
Indirect effect via number of spikelets/spike (NSeS),	r46P4 =	-0.0176	-0.0022	-0.0409	0.0041	0.1386	0.2789
Indirect effect via biological yield/plant (BYP),	r56P5 =	0.0560	0.3982	1.1469	0.4959	0.4378	0.4318
Indirect effect via seed index (SI),	r67P7 =	-0.0005	-0.0028	0.0020	-0.0024	-0.0170	-0.0072
Indirect effect via harvest index (HI),	r68P8 =	-0.0018	0.0694	-0.2910	-0.0037	-0.3366	-0.1710
Indirect effect via thrashing index (TI),	r69P9 =	0.0164	-0.0391	0.0189	-0.1064	-0.5458	-0.5348
Total	=	0.9490	0.9330	0.7260	0.8779	0.5610	0.3630

Table 8. Continued.

			All families		50 Selections		10 Selections	
			F4	F5	F4	F4	F5	F4
7- Seed index (SI),	**r**	**=**	**0.4390**	**0.2930**	**0.0610**	**0.2440**	**0.1100**	**-0.3740**
Direct effect,	P7	=	-0.0014	**-0.0090**	**0.0667**	**-0.0067**	**-0.0607**	**0.0622**
Indirect effect via plant height (PH),	r17P1	=	0.0005	**0.0005**	**0.0114**	**0.0271**	**0.2460**	**-0.1590**
Indirect effect via spike length (LS),	r27P2	=	-0.0008	**-0.0004**	**-0.0063**	**-0.0026**	**0.1536**	**0.0078**
Indirect effect via number of spikes/plant (NSP),	r37P3	=	-0.0019	**-0.0017**	**-0.1006**	**-0.0202**	**-0.5918**	**-0.2192**
Indirect effect via number of spikelets/spike (NSeS),	r47P4	=	0.0026	**0.0020**	**0.0849**	**0.0177**	**0.2529**	**0.3680**
Indirect effect via biological yield/plant (BYP),	r57P5	=	0.0152	**0.1136**	**-0.4392**	**0.1373**	**0.0021**	**-0.3237**
Indirect effect via weight of spikes/plant (WSP),	r67P7	=	0.3293	**0.1600**	**-0.0044**	**0.1761**	**0.2605**	**-0.0595**
Indirect effect via harvest index (HI),	r78P8	=	-0.0025	**0.0382**	**0.4486**	**-0.0098**	**0.0426**	**0.0701**
Indirect effect via thrashing index (TI),	r79P9	=	0.0981	**-0.0102**	**-0.0001**	**-0.0747**	**-0.1952**	**-0.1205**
Total		**=**	**0.4390**	**0.2930**	**0.0610**	**0.2440**	**0.1100**	**-0.3740**
8- Harvest index (HI),	**r**	**=**	**0.5130**	**0.4970**	**0.1170**	**0.3780**	**0.3850**	**0.4840**
Direct effect,	P8	=	-0.0056	**0.2650**	**0.9731**	**0.4097**	**0.9901**	**0.6427**
Indirect effect via plant height (PH),	r18P1	=	0.0041	**0.0004**	**0.0135**	**-0.0041**	**0.1569**	**-0.1024**
Indirect effect via spike length (LS),	r28P2	=	0.0071	**0.0002**	**0.0017**	**0.0005**	**-0.1340**	**-0.0025**
Indirect effect via number of spikes/plant (NSP),	r38P3	=	0.0009	**-0.0004**	**-0.0869**	**-0.0064**	**-0.3553**	**-0.1004**
Indirect effect via number of spikelets/spike (NSeS),	r48P4	=	0.0009	**0.0010**	**0.0841**	**0.0076**	**0.1702**	**0.1292**
Indirect effect via biological yield/plant (BYP),	r58P5	=	0.0022	**-0.0061**	**-0.9287**	**-0.1732**	**-0.6528**	**-0.3591**
Indirect effect via weight of spikes/plant (WSP),	r68P7	=	0.2859	**0.1330**	**0.0440**	**-0.0044**	**-0.3163**	**-0.1377**
Indirect effect via seed index (SI),	r78P8	=	-0.0006	**-0.0013**	**0.0308**	**0.0002**	**-0.0026**	**0.0068**
Indirect effect via thrashing index (TI),	r89P9	=	0.2181	**0.1051**	**-0.0147**	**0.1481**	**0.5287**	**0.4073**
Total		**=**	**0.5130**	**0.4970**	**0.1170**	**0.3780**	**0.3850**	**0.4840**
9- Thrashing index (TI),	**r**	**=**	**-0.3520**	**-0.1260**	**0.1040**	**0.0390**	**-0.0930**	**-0.3070**
Direct effect,	P9	=	-0.3046	**-0.1693**	**0.0253**	**-0.2116**	**-0.7097**	**-0.6927**
Indirect effect via plant height (PH),	r19P1	=	-0.0010	**0.0007**	**-0.0050**	**0.0171**	**-0.0355**	**0.0300**
Indirect effect via spike length (LS),	r29P2	=	-0.0015	**-0.0005**	**-0.0071**	**-0.0023**	**0.2375**	**0.0091**
Indirect effect via number of spikes/plant (NSP),	r39P3	=	-0.0010	**0.0003**	**0.0258**	**-0.0071**	**-0.1555**	**-0.1729**
Indirect effect via number of spikelets/spike (NSeS),	r49P4	=	0.0001	**-0.0006**	**-0.0254**	**0.0056**	**0.0490**	**0.2888**
Indirect effect via biological yield/plant (BYP),	r59P5	=	-0.0007	**0.0911**	**0.7679**	**0.2812**	**0.5602**	**0.1982**
Indirect effect via weight of spikes/plant (WSP),	r69P7	=	-0.0478	**0.1173**	**-0.1099**	**0.2453**	**0.7153**	**0.3996**
Indirect effect via seed index (SI),	r79P8	=	0.0004	**-0.0005**	**-0.0003**	**-0.0024**	**-0.0167**	**0.0108**
Indirect effect via harvest index (HI),	r89P9	=	0.0040	**-0.1646**	**-0.5673**	**-0.2868**	**-0.7376**	**-0.3779**
Total		**=**	**-0.3520**	**-0.1260**	**0.1040**	**0.0390**	**-0.0930**	**-0.3070**
10- Res. Effect		**=**	Neglected	Neglected	Neglected	Neglected	Neglected	Neglected

The clear values of the indirect effect of biological yield/plant onto grain yield/plant were 0.0013 and 0.0055 in 500 F_4 families and decreased to -0.0008 and -0.2662 in 10 F_5 early selections through seed index and weight of spikes/plant and to -0.0832 in 10 F_5 late selections via seed index, but vice versa increased to 0.2152 via weight of spikes/plant in group *a* of path analysis, respectively (Table 6). Same trend could be found for indirect effects of biological yield/plant on grain yield/plant as recorded -0.0003 and 0.0252 decreased to -0.2171 and -0.5360 in 10 late selections, but vice versa increased to 0.2548 and 0.2114 in 10 F_5 early selection thrashing index and weight of spikes/plant in group *b* of path analysis, respectively (Table 7). The indirect effect of biological yield/plant on grain yield/plant were 0.0152 and 0.0022 in 500 F_4 families and decreased to 0.0021 and -0.6528 in 10 F_5 early selections and to -0.3237 and -0.3591 in 10 F_5 late selections through seed index and harvest index of group *c* of path analysis, respectively (Table 8). Otherwise, the indirect effect of biological yield/plant onto grain yield/plant were 0.0142, 0.0255, 0.0366, 0.0348, 0.0560 and -0.0007 in 500 F_4 families increased to 0.1542, 0.2482, 0.1895, 0.2072, 0.4378 and -0.5602 in 10 F_5 early selection and 0.2190, 0.1040, 0.0665, 0.0769, 0.4318 and 0.1982 in 10 F_5 late selections via plant height, spike length, number of spikes/plant, number of spikelets/spike, weight of spikes/plant, and thrashing index for group c of path analysis, respectively (Table 8).

These results through the successive cycles of selection provided that both of weight of spikes/plant and biological yield/plant had exerted to be powerful traits as yield components and must be given preference to select superior genotypes of wheat.

Its obvious result that the replacing thrashing index in group *b* instead of seed index in group *a* of path analyses reduced the residual effects from 0.3867, 0.7318, 0.8101 and 0.8392 to 0.2521, 0.4532, 0.3779 and neglected values across 500 F_4 families, 50 F_4 selections, 10 F_5 early pedigree line selections and 10 F_5 late selections, respectively, revealing the effect of traits pattern in path analysis. Furthermore, the residual effects were neglected values across all generations in group *c* of path analysis due to including all studied traits. Consequently, about 85, 46, 34 and 30% in group *a,* 94, 79, 86 and ≈ unit in group *b* and ≈ unit in all cases in group *c* of phenotypic variance ($1-R^2$) in grain yield/plant could be explained by the selected traits of path analysis in 500 F_4 families, 50 F_4 selection, 10 F_5 early selections and 10 F_5 late selections, respectively (Table 6 and 8).

There are two important remarks must be taken into account interest issues i.e., *a)* the direct and indirect effects of weight of spikes and biological yield were decreased or increased from F_3 base population or 500 F_4 families to 10 F_5 early and late selections. This result was coupled with *b)* decreasing or increased the variances ($1-R^2$) exhibited from the path analysis (Tables 6 and 8). Otherwise, the residual factors were increased from started to the end generations in group *a* and *b*, except for late selections in group *b* was decreased to neglected value. All of residual effects in group *c* were neglected estimates into all generations.

These referenced results are indicating that the genes controlling the weight of spikes and biological yield in main view and other yield attributes in the proposed path analyses exerted the maximum genetic expression of their controlling genes. Consequently, the selection should be directed to other traits in next generations.

Different values of direct and indirect effects of yield attributes onto grain yield of wheat proposed by many studies *i.e.* Fouad (2018), Ojha *et al.,* (2018), Shamuyarira *et al.,* (2019), AL-Najjar and AL-Zubaidy (2020), Barman *et al.,* (2020), Baye *et al.,* (2020), Elmassry and El-Shal (2020), Abdulhamed *et al.,* (2021), Poudel *et al.,* (2021), Kadan *et al*., (2022) and Stojsin *et al.,* (2022).

Conclusion

Results revealed that both of weight of spikes/plant and biological yield/plant had exerted to be powerful traits as a yield component and must be given preference to select superior genotypes of wheat.

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تحليل معامل المرور للمحصول وبعض مساهماته في قمح الخبز

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الملخص

يعتبر تحليل معامل المرور من أهم الطرق الإحصائية التي يمكن أن تساعد المربى على تمييز عشائر المحاصيل أثناء برنامج الانتخاب واختيار التراكيب الوراثية المرغوبة ذات الإنتاجية العالية. تم تطبيق تحليلات معامل المرور لمعرفة التأثيرات المباشرة وغير المباشرة على محصول الحبوب/النبات من خلال ثلاث أنماط كما يلي: -

أ- معامل البذور والمحصول البيولوجي ووزن السنابل/النبات.

ب- معامل الانفراط والمحصول البيولوجي ووزن السنابل/النبات.

ج- جميع الصفات محل الدراسة المساهمة في محصول الحبوب.

وتم تطبيق أنماط معامل المرور الثلاثة خلال الجيل الرابع والخامس للانتخاب المبكر والمتأخر.

أظهر تحليل معامل المرور انخفاض التأثير المباشر للمحصول البيولوجي ووزن السنابل/النبات على محصول الحبوب بدءاً من الأجيال الأولى الى الأجيال الانتخابية النهائية في الثلاث مجموعات فيما عدا المنتخبات المبكرة النهائية والتي سجلت قيماً عالية لوزن السنابل النمط الثاني والثالث لمعامل المرور. وعلى العكس من ذلك فقد زاد التأثير المباشر لمعامل الحصاد على محصول الحبوب بدءاً من بداية الانتخاب حتى المنتخبات النهائية. وتشير هذه النتائج الى أن التأثيرات المباشرة لهذه الصفات الثلاثة على محصول الحبوب استجابت بطرق مختلفة وفقا للتغير في تركيبها الوراثي عبر الأجيال الانتخابية المختلفة وأيضا نمط تحليل معامل المرور.