Genetic Path Analysis and Correlation Studies of Yield and Its Components of Some Bread Wheat Varieties

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Abstract. The research was applied in one of the farmers’ fields in Al-Khalidiyah / Anbar Governorate to determine the most appropriate traits to improve the yield of wheat grains during the two seasons 2017-2018 and 2018-2019. The experiment was carried out according to the randomized complete block design with three replicates, with aim of studying the path coefficient of the yield and its components for seven varieties of bread wheat (IPA 99, Bahooth 85, Iraq, Abu Ghrabi 3, Tamoz 2, Sham 6, and Al-Rasheed). Most of the traits showed a significant positive correlation with grain yield. Also, the results of the analysis of the genetic path coefficient indicated that the indirect effect of the number of total tillers on the individual plant yield through the number of productive tillers, was 0.729 and 0.805 for the two seasons respectively, and very close to the direct effect of the number of productive tillers in the individual plant yield 0.887, 0.920. Also, the direct effect of the weight of 1000 grains on the yield of the plant was positive 0.514, 0.707, for the two seasons respectively, and its negative indirect effect of the number of productive tillers. Likewise, the direct effect was positive for the harvest index on individual plant yield and its indirect positive effect with the number of productive tillers. The study recommends focusing on breeding and improvement programs on the characteristics of the number of productive tillers, the weight of 1000 grains, and the harvest index is the best selection index to improve the cereal yield due to its significant correlation and its direct and high impact on the yield.

1. Introduction

The wheat crop (Triticum aestivum L.) is unique among all cereal crops in terms of importance and is considered one of the most important strategic grain crops in reducing the food gap, which has become the problem of the world [1], as it supplies the world’s population with more than 20% of Energy. The improvement of cereal crops depends on the continuous processing of new genetic materials that carry different genes, granting many of the desired agricultural characteristics. To meet the growing demand for wheat, it is necessary to work to increase the yield using new genetic resources in the genetic improvement programs for wheat on the one hand and to improve the yield components of the wheat on the other hand, and since the yield is the result of interaction with a large number of its components [1]. Therefore, developing high-yielding wheat varieties is the main objective of most plant breeder all over the world, as these programs generate distinct genetic material that carries high repetitions of high-yielding genotypes. Improving the grain yield by selecting for the yield components may be more efficient than selection of the grain yield itself, provided that these characteristics have a high genetic correlation with the yield [2]. To determine the best genotypes with desirable traits and use those later in breeding programs and to choose an appropriate selection index that can help in the success breeding programs. Here it is necessary to conduct studies to analyze the variance, find the relationships between the different characteristics, by analysis correlation coefficient and path analysis between yield and its components. The genetic association arises from the genetic association and the genetic effect of a single gene on multiple phenotypic traits (Pleiotropy) or from relationships of evolutionary origin between the components of the yield, because of the effect of the genetic action. Negative correlation between yield components is also present among a large number of crop plants. Therefore, the success of breeding methods depends on breaking the negative link between the yield components. Path coefficient analysis was used by plant breeders to help identify traits that could be useful as a selection criterion for improving crop yield. The path coefficient divides correlation coefficients into direct and indirect effects within the correlation system of traits. When there is a genetic correlation between two traits, the selection for one of them will produce a change in the other trait. In other words, the response of the correlation to the act of selection will take place. Path parameters show a direct effect.
of the independent variable in the dependent variable, as well as an indirect effect of the independent variable in the dependent variable through another independent variable [3]. Although studies that include estimating the correlations between the cereal yield and its components help in identifying the main components affecting the cereal yield, they do not provide sufficient information on the relative importance of the direct and indirect effects contained in individual factors. These considerations are especially noticed in cereal crops where the yield components consist in succession and therefore may interact with compensatory patterns during the stages of plant development. Thus, simple correlations may not give a clear picture of the importance of each component in determining cereal yield [4]. It has been suggested that the components of the yield have a direct or indirect effect on the yield of the grains. Therefore, the path coefficient analysis is the most common statistical method and is used for the purpose of determining the amount of direct and indirect effects of different characteristics in a responding trait (usually the grain yield). In order to achieve the desired goal of breeding programs, it is necessary to study the relationship between the yield and its components, as well as the direct and indirect impact of the components of the yield with the grain yield.

Preferably reformulate the phrase as follows. The study aims to determine the trait or traits that effect on the grain yield through use of correlation and path analysis as a selective indicator for a number of wheat varieties.

2. Materials and methods

2.1. Plant materials

This experiment was carried out in one of the farmers' fields in the Khalidiya area - Anbar Governorate during the two seasons 2017-2018 and 2018-2019 to determine the most appropriate traits to improve the yield of wheat grains and count them as selection criteria through studying and analyzing the path coefficient at the level of the genetic correlation coefficient. A randomized complete block design with three replications was used, which included seven varieties of bread wheat (IPA 99, Buhooth 85, Iraq, Abu Ghraib 3, Tamoz 2, Sham 6, and Al-Rasheed). The characters studied were, total number of tillers, the number of productive tillers, the area of the flag leaf, the biological yield, the number of seeds per spike, the weight of 1,000 grains, and the harvest index as a selection index to improve grain yield planting was carried out in lines of 4 m in length and the distance between one line and another 0.2 m, and eight lines for each variety.

2.2. Field experiment

The planting date for the first season was on 15/11/2017 and in the second season 17/11/2018, soil and crop service operations were carried out for the two seasons according to the applicable recommendations and urea fertilizer was used (46% N) at a rate of 200 kg N. ha⁻¹ split at three stages (When three full leaves appear, the second knot appears on the main stem, and at the booting stage), and triple superphosphate fertilizer (45% P₂O₅) at a rate of 100 kg P₂O₅. ha⁻¹ was added in one dose when preparing the soil [5]. When there is genetic correlation between seed yield and the influencing traits, we start analyzing the path coefficient according to the method established by Wright [6].
Xi: causal variables (the seven characteristics that went into the path coefficient analysis)
Y: dependent variable (grain yield character)
R: the remaining variables
→: A vector representing a path coefficient from the causer to the Pxy transponder
↔: vector representing the correlation coefficient between two rXiYj traits.

Solving this matrix using a computer, the path coefficients was calculating according to the method developed by Li [7] and used by Singh and Chaudhary [8]. The significance of the values of direct and indirect effects proposed by Lenka and Mishra.

### 3. Result and Discussion

The importance of partitioning genetic correlation in the analysis of path coefficient in identifying the direct and indirect effects of the characters contributing to the grain yield of seven varieties of wheat crop in order to know the individual contribution of the various characters in the wheat yield in order to determine the most influential characters as a criterion for selection and to verify the size of the contribution of each character to plan a program efficient in breeding of the wheat crop. The variables chosen in this study as independent variables are the number of total tillers, the number of productive tillers, flag leaf area, biological yield, number of seeds per spike, weight of 1,000 grains, and the harvest index.

In table 1 showed that there was a positive and significant correlation between both the numbers of total tillers with the plant yield (0.696, 0.773) for the two seasons respectively. As well as, the significant positive correlation between the number of productive tillers and plant yield (0.868, 0.913) for the two seasons respectively. The total number of tillers was significant positive associated with the number of productive tillers (0.822 and 0.875) for the two seasons respectively. Rephrase the phrase accurately, especially in the second season, the most significant link between the studied traits (biology yield and harvest index).

The results also indicated a positive and significant correlation between the weight of 1000 grains and the yield (0.640, 0.638), as well as a positive and significant correlation between the weight of 1000 grains and the harvest index, which was reflected in a high and significant correlation between the yield and the harvest index. This is consistent with [9, 10] who indicated that there is a correlation of grain yield with the number of tillers.

|     | TTN  | FTN  | FLA  | BY   | GNS  | ThGW | HI   | PY  |
|-----|------|------|------|------|------|------|------|-----|
| TTN | 1.000|      |      |      |      |      |      |     |
| FTN |      | 1.000|      |      |      |      |      |     |
| FLA |      |      | 1.000|      |      |      |      |     |
| BY  |      |      |      | 1.000|      |      |      |     |
| GNS |      |      |      |      | 1.000|      |      |     |
| ThGW|      |      |      |      |      |      | 1.000|     |
| HI  |      |      |      |      |      |      |      | 1.000|

### Table 1. Correlation coefficient between traits for two seasons

- NTT = number of total tillers
- FTN = number of productive tillers
- FLA = flag leaf area
- BY = biological yield
- GNS = number of grains per spike
- ThGW = weight of 1,000 seed
- HI = harvest index
- PY = individual plant yield

* significant at 5%  ** significant at 1%
The results of presented in Table (2) showed that the number of total tillers has a direct positive effect, and its effect was 0.108 and 0.098 for the first season respectively. As for the indirect effects, they were through the number of productive tillers, they were high and positive for the two seasons (0.729, and 0.805) respectively. Paraphrasing the sentence again because there is an interference in interpretation of the results between leaf area and biological yield. The indirect effects through number of grains per spike were negative in both seasons. The indirect effects by weight of 1000 seed showed a negative effect in both seasons. The highest negative effect was in the second season (-0.112). As for the indirect effects with the harvest index, negative effects were recorded, the highest effect was in the first season (-0.177). We note from the results presented in table (2) that the genetic correlation coefficient was positive in both seasons, and it reached 0.696 and 0.773 respectively. This is also found by [11,12,13,14,15].

The results of presented in Table (3). The direct effect of the productive tillers was positive on the grain yield for the two seasons, (0.887 and 0.920) respectively, while the genetic correlation values for this trait with the grain yield reached 0.868 and 0.913 for the two seasons in respectively. Which indicates that the largest contribution was to the direct effects between the number of productive tillers and grain yield, while the indirect effects were less important, as the indirect effect was through the total tillers at low positive values of 0.089 and 0.086 for the two seasons respectively, and negative effects for each of the area of the flag leaf and the number of grains per spike and the weight of 1000 seed for the two seasons. While the effects were positive in the biological yield 0.262, 0.225 for the two seasons respectively, the effects were positive and low with the harvest index [16,17,18].

| Effect type                              | Genetic path coefficient value |
|------------------------------------------|--------------------------------|
| Direct effect                            | 0.108                          |
| Indirect effect through productive tillers | r12p2y 0.729                   |
| Indirect effect through biological yield  | r13p3y -0.029                  |
| Indirect effect through flag leaf area    | r14p4y 0.440                   |
| Indirect effect through no. of grain per spike | r15p5y -0.014                 |
| Indirect effect through 1000 seed weight | r16p6y -0.073                  |
| Indirect effect through harvest index     | r17p7y -0.078                  |
| Total effect of total tillers on grain yield | r1y 0.696                     |

Table 2. Genetic path analysis values between the grain yield and total number of tillers, upper values for first season, and lower values for second season.

| Effect type                              | Genetic path coefficient value |
|------------------------------------------|--------------------------------|
| Direct effect                            | 0.887                          |
| Indirect effect through total number of tillers | r12p1y 0.920                |
| Indirect effect through flag leaf area    | r23p3y -0.003                  |

Table 3. Genetic path analysis values between the grain yield and total number of productive tillers, upper values for first season, and lower values for second season.

| Effect type                              | Genetic path coefficient value |
|------------------------------------------|--------------------------------|
| Direct effect                            | 0.887                          |
| Indirect effect through total number of tillers | r12p1y 0.920                |
| Indirect effect through flag leaf area    | r23p3y -0.003                  |
The direct effects between flag leaf area and grain yield were -0.098 and -0.112 for the two seasons respectively (Table 4), while the values of the genetic correlations of this trait with the grain yield were 0.107 and 0.188 for the two seasons respectively, indicating that the net indirect effects across other traits were positive for the total number of tillers, number of productive tillers, biological yield, and weight of 1000 grains. The indirect effect was through number of grains per spike and harvest index has negative effects for both seasons. This is found by [19, 20].

Table 4. Genetic path analysis values between the grain yield and flag leaf area, upper values for first season, and lower values for second season.

| Effect type                           | Genetic path coefficient value |
|--------------------------------------|--------------------------------|
| Direct effect                        | -0.098                         |
| Indirect effect through total number of tillers | r13p1y 0.018 \(\rightarrow 0.074\) |
| Indirect effect through productive tillers | r23p2y 0.023 \(\rightarrow 0.090\) |
| Indirect effect through biological yield | r34p4y 0.207 \(\rightarrow 0.164\) |
| Indirect effect through no. of grain per spike | r35p5y -0.105 \(\rightarrow 0.099\) |
| Indirect effect through 1000 seed weight | r36p6y 0.196 \(\rightarrow 0.113\) |
| Indirect effect through harvest index | r37p7y -0.029 \(\rightarrow 0.042\) |
| Total effect of total productive tillers on grain yield | r3y 0.107 \(\rightarrow 0.188\) |

The direct effects between biological yield and grain yield were high and positive 0.505 and 0.489 for the two seasons respectively (Table 5), As for the indirect effects, through the number of total tillers and the number of productive tillers, they were positive for both seasons. The indirect effects through flag leaf area, and the number of grains per spike, they were negative in both seasons. Indirect effects through 1000 seed weight varied between the two seasons, although it is positive. The indirect effects through the harvest index were negative for both seasons. Correlation coefficient was positive for both seasons. This is in line with the findings of Al-Ayfari & Al-Muaini [21].

The overall effect that represents the value of the correlation between the number of grains per spike and yield is positive 0.029, 0.050 and for both seasons (Table 6). The direct effect was positive and reached 0.251 and 0.386 for the two seasons respectively. While the indirect effects were negative through the number of total tillers, the number of productive tillers, the biological yield, and a weight of 1000 seeds, while it was positive through flag leaf area and harvest index, this is similar to what found by Abbas et al. [22].
Table 5: Genetic path analysis values between the grain yield and biological yield, upper values for first season, and lower values for second season.

| Effect type                                          | Genetic path coefficient value |
|------------------------------------------------------|-------------------------------|
| Direct effect Direct                                 | 0.505                         |
| Indirect effect through total number of tillers      | r14p1y 0.032                  |
| Indirect effect through productive tillers           | r24p2y 0.007                  |
| Indirect effect through flag leaf area               | r34p3y -0.080                 |
| Indirect effect through no. of grain per spike       | r45p5y -0.245                 |
| Indirect effect through 1000 seed weight            | r46p6y 0.006                  |
| Indirect effect through harvest index                | r47p7y -0.166                 |
| Total effect of total productive tillers on grain yield | r4y 0.139                    |

Table 6: Genetic path analysis values between the grain yield and number of seed per spike, upper values for first season, and lower values for second season.

| Effect type                                          | Genetic path coefficient value |
|------------------------------------------------------|-------------------------------|
| Direct effect Direct                                 | 0.251                         |
| Indirect effect through total number of tillers      | r15p1y -0.030                 |
| Indirect effect through productive tillers           | r25p2y -0.098                 |
| Indirect effect through flag leaf area               | r35p3y 0.041                  |
| Indirect effect through biological yield             | r45p4y -0.112                 |
| Indirect effect through 1000 seed weight            | r56p6y -0.019                 |
| Indirect effect through harvest index                | r57p7y 0.064                  |
| Total effect of total productive tillers on grain yield | r5y 0.029                    |

The results of presented in Table (7). The direct effect of the weight of 1000 seed with grain yield was high and positive and reached 0.514 and 0.707 for the two seasons respectively, and it agreed with the genetic correlations between these two characteristics which were highly positive significant and reached 0.640 and 0.683 respectively for the two seasons. It is noted that the net indirect effects across other characters did not significantly affect the values of direct effects for the two seasons, and the highest positive indirect effect was 0.404 and 0.559 through harvest index for the two seasons respectively. Whereas the net indirect effects carried a negative value and the highest negative indirect effect came through the number of productive tillers, which amounted to -0.157, -0.275, for the two seasons respectively. This is similar to that found by Al-Juburi et al. [23].
Table 7: Genetic path analysis values between the grain yield and 1000 seed weight, upper values for first season, and lower values for second season.

| Effect type                                      | Genetic path coefficient value |
|--------------------------------------------------|--------------------------------|
| Direct effect Direct                             | 0.514                          |
| Indirect effect through total number of tillers  | r16p1y -0.092                  |
| Indirect effect through productive tillers       | r26p2y -0.157                  |
| Indirect effect through flag leaf area           | r36p3y -0.018                  |
| Indirect effect through biological yield         | r46p4y -0.019                  |
| Indirect effect through 1000 seed weight        | r56p5y 0.073                   |
| Indirect effect through harvest index            | r67p6y 0.559                   |
| Total effect of total productive tillers on grain yield | r6y 0.640                        |

It is noted from the results of Table 8 that the direct effects of the harvest index in the grain yield was positive and moderate and reached 0.168 and 0.244 for the two seasons respectively, as well as the values of genetic correlations between these two characteristics were highly significant and reached 0.661 and 0.707 for the two seasons respectively. It also turns out that the indirect effects also contributed to the development of this positive relationship in most of the characteristics. The maximum positive indirect effect came through the number of productive tillers, which was 0.257, 0.297 for the two seasons respectively. Whereas, the maximum negative indirect effects were by total number of tillers. This is similar to that found by Baktash et al., [24], that the harvest index was one of the most contributing characteristics to the grain yield, because it has the highest direct and indirect effects and the highest values of the genetic correlation coefficient with the grain yield. It differs with what found by Assaf et al., and Khan et al., [25, 26], as it was found that the evidence of the harvest index gave a negative direct effect on the grain yield.

Table 8: Genetic path analysis values between the grain yield and harvest index, upper values for first season, and lower values for second season.

| Effect type                                      | Genetic path coefficient value |
|--------------------------------------------------|--------------------------------|
| Direct effect Direct                             | 0.168                          |
| Indirect effect through total number of tillers  | r17p1y -0.049                  |
| Indirect effect through productive tillers       | r27p2y 0.257                   |
| Indirect effect through flag leaf area           | r37p3y 0.037                   |
Indirect effect through biological yield

Indirect effect through number of seed per spike

Indirect effect through 1000 seed weight

Total effect of total productive tillers on grain yield

4. Conclusion

We conclude through the values of the genetic correlation that the number of productive tillers and the weight of 1000 grains and the harvest index are the most affected by the grain yield because they have a significant positive correlation and were characterized by having direct and indirect effects on the grain yield through other characteristics in addition to the positive and significant correlation coefficient in the two seasons and therefore can be relied upon on the characteristics of the number of productive tillers, weight of 1000 grains, and the harvest index as selection index to improve the grain yield in the breeding program.

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