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Research Article

Evaluation of inheritance pattern for leaf rust resistance genes and heritability estimates for agronomic traits in F_2 progenies of bread wheat genotypes

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Abstract

The current experiment was conducted at experimental farm of Nuclear Institute of Agriculture, Tandojam, during the growing season of 2013-14, which comprised of seven wheat genotypes including four leaf rust resistant (Sunco, Vasco, SD-222 and SD-333) and three susceptible (TD-l, ICARDA and SD-888). These wheat genotypes were used to develop four F_2 cross combinations (TD-1 × Vasco, ICARDA × SD-222, TD-1 × Sunco and SD-888 × SD-333) for the estimation of heritability and genetic pattern of resistance genes. The observations were recorded on gain yield associated traits to evaluate genetic potential of the F_2 populations. The analysis of variance revealed significant differences ($P \leq 0.05$) among the genotypes for all the studied traits which suggested that the breeding material is worth for selection of desirable plants from subsequent segregating generations. With regards to heritability percentage in broad sense, the F_2 progeny TD-1 × Sunco expressed high heritability for days to 75% heading (h^2=60.80%, GA=1.82), days to 75% maturity (h^2=71.50%, GA= 2.40) and tillers plant^{-1} (h^2=32.72%, GA= 12.44). Similarly, the F_2 progeny TD-1 × Vasco showed high heritability (h^2=88.89%, GA= 8.07) for plant height; SD-888 × SD-333 revealed high heritability (h^2=92.33%, GA= 29.83) for biological yield plant^{-1}; ICARDA × SD-222 expressed high heritability (h^2=44.61%, GA= 12.77) for harvest index. The present findings suggest that most of the yield associated traits have been successfully transmitted. The information generated will be helpful for better understanding and selection of desirable material especially in early generations. Furthermore, phenotypic data expressed 3:1 ratio in F_2 populations of four crosses which indicated that both *(Lr24* and *Lr32)*

are single dominant genes, thus specifying the usefulness of these genes for the breeders to incorporate in mega wheat varieties susceptible to leaf rust and to save guard the future harvest.
Key words: Inheritance pattern; heritability; F_2 population; Bread wheat

Introduction

In Pakistan, wheat is being used as the staple diet and is grown on the largest acreages in almost every part of the country. Talking about area under wheat cultivation has declined to 9180 thousand hectares in 2014-15 from previous year's area of 9199 thousand hectares that displays a reduction of 0.2 percent. The wheat production stood at 25.478 million tonnes during 2014-15, demonstrating a decrease of 1.9 percent over the preceding year's production (25.979 million tonnes). The decline in production was associated with extended winter season and exceptional rains during the months of April and May which caused damages to grain at harvesting time [1].

The success of any breeding strategy rely on the preservation, creation and utilization of genetic diversity. Higher the genetic diversity in crop germplasm, higher the chances of getting sustainable progress in genetic improvement of crop plants against variety of stresses [2]. Estimation of heritability and genetic advance offers the knowledge about degree of transmission of trait in subsequent generations and selection response. Heritability is the component of phenotype which is being determined by genetic factors [3]. Heritability and genetic advance values help in making selection more efficient and envisaging the selection response. Therefore, trait selection based on high heritability makes the progress easier. For an effective selection, environmental variability must be less in respect to genetic differences [4]. The current research work was planned to estimate variability and genetic parameters for grain yield contributing characters in F_2 populations of bread wheat and also to know the inheritance pattern of leaf rust resistance genes.

Materials and methods

The current investigation was done at the experimental area of Nuclear Institute of Agriculture (NIA), Tandojam during the wheat growing season of 2013-14. The experiment comprised of seven wheat genotypes including four leaf rust resistant (Sunco, Vasco, SD-222 and SD-333) genotypes carrying *Lr-24* and *Lr-32* genes and three rust susceptible (TD-l, ICARDA and SD-888) genotypes. After hybridization, four F_2 progenies (TD-1 × Vasco, ICARDA × SD-222, TD-1 × Sunco and SD-888 × SD-333) were produced and these F_2 progenies were evaluated for inheritance pattern for leaf rust resistance genes. The observations were recorded on gain yield associated traits to evaluate genetic potential of the F_2 populations. The seed of rust spreader (Morocco) and rust inoculum of leaf rust were obtained from head of Plant Breeding and Genetics Division, NIA, Tandojam. The seeds of each parent and their respective F_2 crosses were planted in 4 rows of 2 meter in length with plant to plant distance of 15 centimeter and row to row distance of 30 centimeter in randomized complete block design with four replications. After every 8 experimental lines, a spreader row (Morocco) was planted. The recommended dose of fertilizers and irrigations were applied accordingly. The entire data was statistically analyzed using analysis of variance method as suggested by Gomez and Gomez [5] and the means were compared by Duncan's multiple range test by Statistix v. 8.1 computer package. The heritability of different traits was calculated according to Falconer [6].

Results and discussion

The pooled analysis of variance for all the genotypes including seven parents and their four F_2 progenies revealed that both the

parents and segregating populations differed significantly (P≤0.01) for all the traits under study, showing the existence of abundant genetic variability among the genotypes (Table 1). The results of each traits is discussed in following paragraphs.

Table 1. Mean squares for various morphological traits of four F_2 populations and parental lines of wheat.

Source of variation	Degree of freedom	Characters					
		Days to heading	Days to maturity	Plant height	Tillers plant[1]	Grain yield plant $^{-1}$	Harvest index %
Replications	3	6.57	2.45	5.92	9.22	3.16	0.40
Genotypes	10	235.96**	176.47**	540.22**	163.69**	56.15**	83.61**
Errors	30	2.83	0.83	13.14	5.07	1.67	6.22

****** = Significant at 1% probability level

Days to 75% heading

The mean performance for days to heading is given in (Table 2). Mean performance of four F_2 progenies showed that days to heading ranged from 69.00 to 96.00 days. The F_2 progeny ICARDA × SD-222 took maximum (96.00 days) days to heading and the minimum days to heading (69.00 days) were taken by SD-888 × SD-333, indicating that F_2 progeny SD-888 × SD-333 could be utilized for the development of early maturity wheat varieties. It has been reported that higher the heritability, more effective would be the selection, whereas the high estimates are attributed to fixable component of genetic variation. The high heritability associated with low genetic advance is probably due to non-additive gene (dominance and epistasis) effects [7]. The broad sense heritability and genetic advance for days to heading was ranged from 13.74 to 76.22% and 0.63 to 5.36, respectively. The high heritability (h^2 = 76.22%) coupled with low genetic advance (GA = 2.23) was found in cross combination TD-1 x Sunco. This trait can easily be fixed in the genotypes by selection in early generations.

Days to 75% maturity

The mean performance for days to maturity (Table 2) revealed that maximum days to maturity were taken by parental line SD-333 (139.00 days) and SD-888 took minimum days to maturity (122.00 days). While, TD-1 × Sunco took maximum days to maturity (132.00 days) and the minimum days to maturity were recorded in TD-1×Vasco (123.00 days). Early maturing cultivars are required to escape and combat with many abiotic and biotic stresses and also to vacate the field in time to grow other crops at proper time. These genotypes (SD-888 and TD-1 × Vasco) may be considered to develop early maturing wheat cultivars. The heritability of a character describes the extent to which it is transmitted from one generation to the next. TD-1 × Sunco expressed high heritability (h^2 = 71.50%) but coupled with low genetic advance (GA=2.40). It indicated that early maturity is caused by the additive effect of genes. This trait could be fixed by selecting the genotypes with less number of days to mature.

Plant height (cm)

The mean performance (Table 2) for plant height showed that the cross combination ICARDA × SD-222 grew taller plants of 106.00 cm and the short stature plants of 80.18 cm were observed in TD-1 × Sunco. It is well known fact that dwarf varieties are quiet useful in wheat since these genotypes show better response for nitrogen uptake and also exhibit greater resistance against lodging. So, the cross combination TD-1 × Sunco could particularly be utilized to

develop short stature wheat varieties. All cross combinations showed high heritability percentage; however, among all cross combinations, TD-1 × Vasco showed the highest heritability (h^2 = 88.89%) coupled with low genetic advance (GA=8.07). These results are in agreement with those of Asif [8] and Hussain [9].

Tillers plant^{-1}

The maximum number of tillers plant^{-1} (21.17) was recorded in TD-1 × Sunco and minimum tillers plant^{-1} (11.00) were observed in SD-888 × SD-333. Number of tillers plant^{-1} is controlled by the genetic factors and expressed by transgression to their hybrids [10]. So, selection for number of tillers plant^{-1} would be useful for wheat breeders to improve wheat grain yield plant^{-1}. High heritability (h^2 = 63.66%) was shown by the F_2 progeny SD-888 x SD-333 coupled with high genetic advance (GA=24.80). Ansari [11] reported high heritability coupled with high genetic advance in bread wheat hybrids for tillers plant^{-1}. He suggested that the selection scope for the tillers plant^{-1} would be more effective for the improvement of trait and for yield as well. It could be suggested that selection of tillers plant^{-1} would be more effective for improvement of grain yield in wheat crop.

Table 2. Means performance of seven parental lines and their four F_2 populations of wheat for various traits

Parents and F_2 progenies	Days to 75% heading	Days to 75% maturity	Tillers plant^{-1}	Plant height (cm)	Biological yield plant^{-1} (g)	Harvest index (%)
TD-1	85.00d	127..00c	19.11b	68d	66.12a	17.92b
Vasco	89.00bc	138.00a	21.00b	80c	61.63ab	15.15bc
Sunco	97.00a	138.00a	25.33a	80c	64.82 a	11.91cd
ICARDA	85.00d	138.00a	21.25b	97b	55.11abc	14.26bcd
SD-222	90.00b	131.00b	14.06c	84c	40.57d	11.04d
SD-888	85.00d	122.00e	7.00d	64d	27.31e	17.87b
SD-333	86.00a	139.00a	5.00d	79c	23.95e	17.77b
TD-1 × Vasco	87.00cd	123.00e	19.66b	85c	59.78ab	28.51a
ICARDA × SD-222	96.00a	126.00c	14.58c	106.00a	46.00cd	16.49b
TD-1 × Sunco	79.00b	132.00b	21.00b	80c	59.71ab	17.69b
SD-888 × SD-333	69.00f	124.00d	11.00c	83c	51.77bc	15.61bc
LSD (5%)	2.431	1.31	3.253	5.236	9.785	3.603

Biological yield plant^{-1}

Regarding mean performance (Table 3) of biological yield plant^{-1}, the F_2 progeny TD-1 × Vasco yielded higher biological yield plant^{-1} (59.78 g) than all the parental and F_2 progenies except the parental line TD-1 which produced maximum biological yield plant^{-1} (66.12 g). For the trait biological yield plant^{-1}, low, moderate and high heritability was observed in different F_2 progenies, referring genetic existence of variability in F_2 populations and desirable level of biological yield plant^{-1} may be effectively selected from these crosses. High heritability (h^2=92.33%) found in SD-888 × SD-333 whereas, high genetic advance for biological yield (GA=29.83) was also observed in the same F_2 progeny. Jadoon

[12] reported high heritability and high genetic advance for biological yield.

Table 3. Genetic variance (σ^2g), phenotypic variance (σ^2p), heritability percentage in broad sense (h^2 b.s) and genetic advance (GA) for various traits in 4 F_2 generations of bread wheat

Characters	F_2 progenies	Genetic variance (σ^2g)	Phenotypic variance (σ^2p)	Heritability (h^2%) broad sense	Genetic advance (GA)
Days to 75% heading	TD-1 × Vasco	0.43	2.25	18.83	0.63
	ICARDA × SD-222	0.80	1.31	60.80	1.82
	TD-1 × Sunco	0.88	1.15	76.22	2.23
	SD-888 × SD-333	0.18	1.31	13.74	5.36
Days to 75% maturity	TD-1 × Vasco	1.11	1.65	67.27	2.30
	ICARDA × SD-222	0.43	1.03	44.83	1.04
	TD-1 × Sunco	1.11	1.55	71.50	2.40
	SD-888 × SD-333	0.11	1.59	6.91	1.80
Plant height	TD-1 × Vasco	1.81	2.03	88.89	8.07
	ICARDA × SD-222	2.06	2.79	69.21	6.80
	TD-1 × Sunco	1.57	2.38	65.61	6.61
	SD-888 × SD-333	1.85	2.09	88.29	8.34
Tillers plant^{-1}	TD-1 × Vasco	1.89	5.94	31.84	1.83
	ICARDA × SD-222	0.71	2.55	27.89	9.82
	TD-1 × Sunco	0.96	2.94	32.72	12.44
	SD-888 × SD-333	0.78	1.22	63.66	24.80
Biological yield plant^{-1}	TD-1 × Vasco	2.07	13.21	15.66	7.61
	ICARDA × SD-222	0.68	11.96	5.72	3.24
	TD-1 × Sunco	3.92	12.16	32.22	17.88
	SD-888 × SD-333	4.12	4.46	92.33	29.83
Harvest index	TD-1 × Vasco	1.00	2.80	35.47	9.74
	ICARDA × SD-222	0.71	1.58	44.61	12.77
	TD-1 × Sunco	0.65	2.36	27.42	9.62
	SD-888 × SD-333	0.75	2.70	27.66	10.85

Introgression of resistance genes

The result of scoring of parental lines and their F_2 progenies indicated that all resistant parents exhibited resistance to the prevailing race of rust, whereas susceptible parents revealed susceptibility in the field. In each F_2 progeny of TD-1 × Vasco, ICARDA × SD-222, TD-1 × Sunco, SD-888 × SD-333 out of 20 plants 14, 14, 16 and 13 were resistant plants; whereas, 6, 6, 4, and 7 were observed susceptible, respectively (Table 4). The 3: 1 ratio based on reaction pattern in the field is an indicative of the involvement of single dominant gene for resistance to leaf rust. These resistant genes could be proved valuable for the development of new resistant cultivars in wheat breeding program to face the new challenges of rust threat in Southeast Asia, especially in Sindh province.

Table 4. Reaction pattern of parental lines and four F_2 populations in the field

F_2 generation/Parents	Expected segregation	Adult plant stage		
		Observed segregation		
		Resistant	Susceptible	x^2
SD-333	Resistant	20	0	0
Vasco	Resistant	20	0	0
Sunco	Resistant	20	0	0
SD-222	Resistant	20	0	0
TD-1	Susceptible	0	20	0
SD-888	Susceptible	0	20	0
ICARDA	Susceptible	0	20	0
TD-1 × Vasco	3.1	14	6	0.266
ICARDA × SD-222	3.1	14	6	0.266
TD1 × Sunco	3.1	16	4	0.266
SD-888 × SD-333	3.1	13	7	1.06

Authors' contributions

Conceived and designed the experiments: AW Baloch, GM Baloch & MA Asad. Performed the experiments: DR Sheikh, N Gandahi & IA Baloch. Analyzed the data: M Baloch & AM Baloch. Contributed reagents/materials/analyses tools: MA Asad & M Ali. Wrote the paper: AW Bloch & M Baloch.

References

1. Anonymous (2014). Pakistan Economic Survey 2013-14. Ministry of Finance, Government of Pakistan, Islamabad. p.19-21.
2. Ijaz F, Khaliq I & Shahzad MT (2015). Estimation of heritability for some yield contributing traits in F_2 populations of bread wheat (*Triticum aestivum* L.). *J Agri Res* 53(2): 157-164.
3. Khan AS, Salim I & Ali Z (2003). Heritability of various morphological traits in wheat. *Inter J Agri Bot* 5(2): 131-140.
4. Khaliq I, Noorka IR & Khaliq R (2009). Estimation of heritability and genetic advance for quantitative characters in spring wheat. *Int J Agri Appl Sci* (1):76-78.

5. Gomez KA & Gomez AA (1984). Statistical procedures for agricultural research. John Wiley & Sons Inc. 2nd (ed.) New York U.S.A.
6. Falconer DS (1977). Introduction to Quantitative Genetics. Richard Clay Ltd. Bungay Sufolk, Great Britain pp.129-185.
7. Larik AS, Kakar AA, Naz MA & Shaikh MA (1999). Estimation of genetic parameters in bread wheat (*Triticum aestivum* L.) crosses. *Sarhad J Agri* 15(1): 203-204.
8. Asif M, Mujahid Y, Kisana NS, Mustafa SZ & Ahmad I (2004). Heritability, genetic variability and path coefficient of traits in spring wheat. *Sarhad J Agri* 20(1):87-91.
9. Hussain F, Rafiq M, Iqbal Z, Iqbal J & Chowdhry MA (2013). Estimates of heritability and genetic advance for grain yield and its components in different segregating populations of wheat. *J Agri Res* 51(4)-349-360.
10. Memon SM, Qureshi D, Ansari BA & Sial MA (2007). Genetic heritability for grain yield and its related characters in spring wheat *(Triticum aestivum* L.). *Pak J Bot* 89(5):1503-1509.
11. Ansari BA, Soomro ZA, Ansari KA & Sethar H (2003). Heritability of grain yield and its components in F_5 population of spring wheat adapted in Sindh province of Pakistan. Pak *J Agri Agri Engg Vet Sci* 19(1): 14-21.
12. Jadoon SA, Mohammad F, Ullah H & Khalil IH (2012). Gene action for pre and postharvest traits in F_2 wheat populations, *Q Science*. http://dx.doi.org/10.5339.