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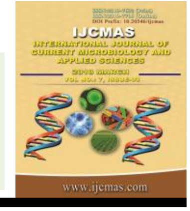

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Genetics of Free Threshability in Tetraploid Wheat

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A B S T R A C T

To study inheritance pattern of threshability, two non-free threshing varieties of dicoccum *viz*., DDK-1025 and DDK-1029 crossed with advanced free threshable line NIDW-295. The non-segregating (P_1, P_2 and F_1) and segregating (F_2, BC_1P_1 and BC_1P_2) were developed and evaluated on individual plant basis for the trait threshability. The chi-square method was followed in order to test goodness of fit and establish gene relationship. Inheritance pattern of free threshability found to be governed by single dominant gene and free threshability is dominant over non-free threshability in F_1 in both the crosses viz., DDK-1025 x NIDW-295 and DDK 1029 x NIDW-295. In the F_2 generations of both the crosses, observations displayed a good fit to the monogenic ratio of 3:1 for free threshability verses non-free threshability. Among the back cross generations, BC_1P_1 (F_1 X DDK 1025 or DDK 1029) generations of both crosses, the data was found to be in good fit with expected ratio of 1:1 for free threshable : non-free threshable. In case of BC_1P_2 (F_1 x NIDW-295), all the plants observed for free threshability fall under free threshable category, which was in conformity with expected free threshable to non-free threshable ratio of 1:0.

Introduction

Dicoccum wheat (*Triticum dicoccum* Schrank Schulb) a hulled wheat, commonly called by different names viz., "Jave, Khapli, Samba, Sadaka, Kavada" etc. In the world, cultivation of these wheats is only confined to few mountainous marginal areas of Italy. In India it is traditionally cultivated in Northern Karnataka, Southern Maharashtra, Sourashtra region of coastal Gujarat, Nilgiris and Palanihilly areas of Tamil Nadu and Telangan region in Andhra Pradesh (Mahantashivayogayya, 2002). Dicoccum wheat differs from commercially available bread and durum wheats in cultivation practices. Due to its nutritional and therapeutic quality traits dicoccum wheats are preferred by many people. This wheat has a great demand in urban areas of central and southern India and also in Srilanka and Maldevas, but due to non-availability of this wheat consumption is often confined to people of growing areas. Non-availability of free threshing varieties, lack of scientific techniques regarding dehulling of dicoccum wheat, value addition, reddish grain colour of the wheat are some of the constraints. In India, dicoccum wheat is mainly processed for preparation of semolina and used in preparation of several conventional dishes like godhi huggi, uppuma, sajjaka, madali, chapati, holige and also in preparation of pasta products like vermicelli (Reddy, 1996).

Scientific studies related to dicoccum wheat also reveal that they are nutritionally superior as compared to commercially available wheat with the high protein and dietary fibre contents (Bhuvaneshwari *et al.,* 1998). Dicoccum based products are more tasty and soft (Reddy, 1996) have high satiety value and a potential of backing, parboiling and popping quality. Products have low digestibility, low glycaemic value and it has been considered as a therapeutic food in the management of diabetes (Yenagi *et al.,* 1999), which is India's leading health problem.

Dicoccum wheats differ from other wheats *viz.,* bread and durum wheats for physical characteristics, nutritional and processing quality parameters. Non availability of free threshing varieties low yield and reddish grain colour are important constraints in cultivation and utilization. The loss incurred on dehulling can be recovered if free threshing dicoccum varieties are developed. The husked grains (non-free-threshing) are governed by the genetic locus 'q' and naked grains trait by 'Q' which is located of chromosome five of genome A (Morris and Sears, 1967). All Triticum diploid progenitors possess the non-free threshing (NFT) habit, while both free-threshing (FT) and NFT forms occur in the tetraploid and the hexaploid groups (Kerber and Rowland 1974). The kernels of the NFT wheat are closely invested in the spikelet by tough tenacious glumes, lemma, and palea that are not readily detached with pressure or vigorous rubbing. Whereas, only slight rubbing or threshing action is required to separate the glumes from the spikelet of FT wheat to separate the grains. MacKey (1966) reported a polygenic system scattered through all three genomes that counteracts rachis brittleness and tough, tenacious glumes. A second system which suppresses these primitive tendencies is that of the Q factor located on chromosome 5A. Inheritance studies of threshability in synthetic hexaploids and 'Canthatch' indicated that a partially dominant gene, apparently introduced from the T. tauschii parent, results in NFT spikelets. Kerber and Rowland (1974), showed dominant gene for tenacious glume, Tg, in 2D of *T. tauschii* and q inhibits the expression of free threshing habit in synthetic hexaploids. Further, understanding the gene action of the threshability is of prime importance in emmer wheat as there is a great need to develop dicoccum varieties with free threshing habit. Hence, the present study aimed to investigate the inheritance pattern of threshability by makes use of advanced free threshable lines.

Materials and Methods

In order to investigate the genetics of threshabilitys in tetraploid wheat, two non-free threshable red grains dicoccum lines (DDK 1025 and DDK 1029) were crossed with one free threshable amber grain durum line (NIDW 295). Segregating and non-segregating generations were developed *viz.,* P_1, P_2, F_1, F_2, BC_1P_1 (F_1 back crossed with P_1) and BC_1P_2 (F_1 back crossed with P_2). These six generations were evaluated under replicated trial on individual plant basis.

For the trait threshability, all the six generations were screened and categorized as free threshable and non-free threshable. Threshability data of individual spikes was recorded after harvest. Spikes were threshed with hand, based on percentage of husked seeds obtained, classified as free threshable and non-free threshable. These observations recorded for individual plants were pooled and utilized for determining the total number of free threshable and non-free threshable for threshability trait in P_1, P_2, F_1, F_2, BC_1P_1 and BC_1P_2 generations. Further, chi-square method was followed in order to test goodness of fit and establish gene relationship. The results obtained are explained below.

Results and Discussion

In the cross DDK-1025 x NDIW-295 (Table 1a), it is clear that the parent DDK-1025 (P_1) was found to be non-free threshable (NF). All the 10 plants of F_1 generation were categorized as free threshable (F).

In case of F_2 population, out of 225 plants scored, 164 plants were registered as free threshable and 61 plants were found to be non-free threshable. Further, these observations displayed a good fit to the monogenic ratio of 3:1 for free threshability verses non-free threshability as indicated by low chi-square value of 0.535 (Table 2a). Among the back cross generations, out of 105 plants screened in BC_1P_1 (F_1 x DDK-1025), 50 plants observed as free threshable. The data was found to be in good fit with expected ratio of 1:1 for free threshable: non-free threshable with the calculated chi-square value of 0.238. The back cross results further confirmed the F_2 monogenic F: NF ratio of 3:1. In case of BC_1P_2 (F_1 x NIDW-295), out of 108 plants observed, 106 fall under free threshable and 2 under non-free threshable category, which was in conformity with expected F: NF ratio of 1:0.

In another cross, DDK-1029 x NIDW-295 and DDK-1029 (P_1) recorded non-free threshability and NIDW-295 (P_2) recorded free threshability. The F_1 generation also showed free threshability (Table 1b).

Further, all the plants of segregating generations were observed for threshability trait. Out of 210 F_2 plants observed, 160 plants categorized as free threshable and 50 as non-free threshable. These observations displayed a good fit to the monogenic F_2 ratio of 3:1 for free threshable to non-free threshable, as it is indicated by low chi-square value of 0.158 (Table 2b.). A total of 110 BC_1P_1 (F_1 x DDK-1029) plants were observed in the cross DDK-1029 x NIDW-295 and 58 plants were categorized as free threshable and 52 plants as non-free threshable. Again this data was also found to be in good fit with expected ratio of 1:1 (F:NF) with the calculated chi-square value of 0.327 which is less than tabe chi-square value of 5.99 at 5 per cent with 2 degrees of freedom.

Out of 100 plants observed in BC_1P_2 (F_1 x NIDW-295) generation, which is a test cross, 96 plants categorized four free threshable and as non-free threshable. This was in conformity with expected F: NF ratio of 1:0 with the calculated chi-square value (0.16) less than table chi-square value.

All these results in both the crosses *viz.*, F_2 ratio of 3:1, back cross generations ratio viz., BC_1P_1 ratio of 1:1 and BC_1P_2 ratio of 1:0 (F:NF) depicted that the trait non-free threshability is controlled by single recessive gene and free threshability is dominant over non-free threshability in F_1. Similar observations were evidenced by Villareal *et al.,* (1996), Luo *et al.,* (2000), Patil (2010) and Nagaraju *et al.,* (2017).

Threshability is one of the important post-harvest traits which is primary interest of the dicoccum breeders. The caryopsis of non-free threshing wheat is closely invested in the spikelet by tough thick tenacious glumes that are not readily detached with pressure and vigours rubbing. On the other hand, only slight rubbing or threshing action is required to separate the glume from the spikelet of free thesing wheat to release the kernel enclosed between the lemma and palea. The glume tenacity is classified as easy as threshing as that of *T. aestivum*.

Table.1 Reaction of parents, F_1, F_2 and back cross generations of *T. dicoccum x durum* cross for threshability

a. Cross: DDK-1025 x NIDW-295

Generation	Free threshable	Non-free threshable	Total
P_1 (DDK1025)	0	10	10
P_2 (NIDW295)	10	0	10
F_1	10	0	10
F_2	164	61	225
BC_1P_1 (F1 × DD1025)	50	55	105
BC_1P_2 (F1 × NIDW295)	106	2	108

b. Cross: DDK-1029 x NIDW-295

Generation	Free threshable	Non-free threshable	Total
P_1 (DDK1029)	0	10	10
P_2 (NIDW295)	10	0	0
F_1	10	0	10
F_2	160	50	210
BC_1P_1 (F1 × DD1029)	58	52	110
BC_1P_2 (F1 × NIDW295)	96	4	100

Table.2 Test of significance of segregation ratios for threshability in *T. dicoccum x T. durum* cross of wheat

a. Cross: DDK-1025 x NIDW-295

Generation	Observed		Total	Expected		Expected ratio		Chi-square value (χ^2)	Table Chi-square value at 5% with 2 df
	F	NF		F	NF	F	NF		
F_2	164	61	225	168.75	56.25	3	1	0.535	
BC_1P_1	50	55	105	52.5	52.5	1	1	0.238	5.99
BC_1P_2	106	2	108	54	54	1	0	0.037	

NF - Non free threshable
F - Free threshable
BC_1P_1 – Back cross generation 1 with parent 1 (DDK-1025)
BC_1P_2 – Back cross generation 1 with parent 2 (NIDW-295)

b. Cross: DDK-1029 x NIDW-295

Generation	Observed		Total	Expected		Expected ratio		Chi-square value (χ^2)	Table Chi-square value at 5% with 2 df
	F	NF		F	NF	F	F		
F_2	160	50	210	157.5	52.5	3	1	0.158	
BC_1P_1	58	52	110	55	55	1	1	0.327	5.99
BC_1P_2	96	4	100	100	0	1	0	0.16	

NF - Non free threshable
F - Free threshable
BC_1P_1 – First back cross generation with parent 1 (DDK-1029)
BC_1P_2 – First back cross generation with parent 2 (NIDW-295)

In this study dicoccum parents have brittle rachis and tough glumes and are non-free threshing with red pericap colour whereas, durum parents were free threshing and amber grained as they have non brittle rachis and easy threshing glumes as that of *T. aestivum*. Generally dicoccum wheats are not preferred by consumers due to its husked seed nature and red grain colour. The husked grains are governed by 'q' and necked grain trait by 'Q' which is located on chromosome five of genome A (Morris and Sears, 1967). Here the non-free threshing types are governed by recessive gene 'q'.

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