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Short Communication

Genetics and linkage studies of free threshing and grain type traits in *Triticum dicoccum* L.

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Among different wheat species grown world wide, emmer wheat is one of the first crops domesticated in early years of civilization. In India, emmer wheat is traditionally cultivated in Northern Karnataka, Southern Maharashtra, Saurashtra region of Coastal Gujarat, parts of Tamil Nadu and Andhra Pradesh. The area of cultivation is about 1.0 hectares with total production of 2.5 lakh tonnes comprising one percent of the total area [1]. Emmer wheat is slowly gaining importance because of its high degree of thermo tolerance in comparison to other wheats. This species also possesses a very high degree of resistance to stem and leaf rust. Nutritional studies of emmer wheat reveal it's superiority over commercially available wheat. It has high protein content (14-15%) and dietary fiber contents (1.2-1.5%). It's low glycaemic index and having low digestibility imparts high therapeutic value in the management of diabetes. Though the yield levels of the other wheat species i.e. *T. aestivum* and *T. durum* are comparable with semi dwarf *T. dicoccum*, the grain recovery is low due to its fragile rachis and non-free threshability. It becomes time consuming and less cost effective. Looking to its quality traits and resistance there is a need to develop free threshing forms. Investigations are made in order to study the inheritance of threshability and linkage with grain morphology.

Among tetraploid species, *T. carthlicum* (= *persicum*) is one of the species with free threshing habit. It is characterized by round glumes along with *Q* locus present on the long arm of chromosome 5A [2]. Q locus pleiotropically affects many agronomically important traits including threshability, glume shape, rachis fragility and tenacity, plant height, spike length, and ear emergence time [3]. Hence *T. carthlicum* was selected for inter specific crossing with *T. dicoccum* in order to study develop free threshing traits.

T. carthlicum var EC 119465 which carries Q locus was crossed as female with *T. dicoccum* var. DDK 1009 having *q* locus. Similarly a reciprocal cross was also attempted at the Agharkar Research Institute's farm situated at Hol. Tal. Baramati of Pune District. Each spike was threshed separately with the help of single head thresher with uniform speed. Threshed and unthreshed grains were counted in order to calculate the threshability index. F_2 data on inheritance have been processed further to study linkages in the joint segregations in the crosses [4]. Threshability of both the parents is given in Table 1. In *T. carthlicum* no unthreshed grains were obtained suggesting the free threshing (FT) habit. In *T. dicoccum* var. DDK 1009, out of 500 spikelets, only 85 spikelets got threshed suggesting the non-free threshing (NFT) character of dicoccum. Dicoccums are characterized by some what long grains with prominent brush, keeled glumes and spikelets dense. F_1 spikes were slightly lax, having keeled glumes, brittle rachis and slender grains with prominent brush resembling dicoccum type grain.

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Table 1. Threshability index of parents

	T. carthlicum var EC 119465	*T. dicoccum* var. DDK 1009
Total no. of sikelets threshed	500	500
Easily threshed	500	85
Unthreshed	0	415
Threshability index	0 (NFT)	83% (FT)

Table 2. Inheritance of threshability

Combination		*T. dicoccum* x *T. carthlicum* var DDK 1009 var EC 119465	Reciprocal
P_1		NFT	FT
P_2		FT	NFT
F_1		NFT	NFT
F_2	NFT	281	204
	FT	92	52
	Total	373	256
	X^2	0.021	3.0
	D.F	1	1
F_2 ratio		3:1	3:1
P value		0.9 -0.8	0.1 -0.05

Inheritance of threshability

It is observed from the parents, their F_1 Hybrids and F_2 individual (Table 2) that the hard threshing character is dominant and governed by single dominant allele and gene responsible for free threshing is present on long arm of chromosome 5A. However four QTL responsible for the origin of the free-threshing characters were reported earlier [5, 6]. Of the four QTL, two with large effect, each accounting for approximately 25% of phenotypic variation, were mapped to the chromosome locations where two major free-threshing loci were previously identified. These were *Tg* on the short arm of chromosome 2B (group 2 chromosome of the B genome) and *Q* on the long arm of chromosome 5A (group 5 chromosome of the A genome). The free-threshing alleles, *tg* and *Q*, were partially recessive and partially dominant, respectively, at these two loci. Here the genotype of the free-threshing tetraploid wheat with the AABB genome is designated as $tgtg^{2B}QQ^{5A}$. The differences between present findings and the earlier

Table 3. Inheritance of grain type

Combination	*T. dicoccum* x *T. carthlicum* var DDK 1009 var EC 119465	Reciprocal
P_1	Dicoccum type grain appearance	Carthlicum type grain appearance
P_2	Carthlicum type grain appearance	Dicoccum type grain appearance
F_1	Dicoccum type grain appearance	Dicoccum type grain appearance
F_2 dicoccum type	277	194
Carthlicum type	96	62
Total	373	256
χ^2	0.108	0.082
D.F.	1	1
F_2 ratio	3:1	3:1
P value	0.5-0.3	0.8-0.7

Table 4. Linkage relationship between threshability and grain type

Cross combination	XY	Xy	xY	xy	χ^2	P value	D.F.
T. carthlicum x *T. dicoccum* var EC 119465 var DDK 1009							
Threshability (3:1) with grain type (3:1)	270	11	7	85	471.36	<.001	3
Expected on linkage value 4.82 % (C.O.)	270.98	8.70	8.76	84.48	0.93	0.50-0.30	2
Reciprocal							
Threshability (3:1) with grain type (3:1)	190	14	4	48	143.17	<0.001	3
Expected on linkage value 6.34% (C.O.)	184.03	7.96	7.96	56.04	1.15	0.30-0.20	2

(C.O. = Cross over %)

***Triticum carthlicum* var. EC 119465** **F_1** ***Triticum dicoccum* var. EC 119465**

reports might be due to different species selected in breeding program which may not possess Q.

Inheritance of grain character

Grains having brush ends were grouped under dicoccum type while rest under carthlicum type. It is observed that dicoccum grain type is dominant with monogenic control (Table 3).

Linkage studies

Results of linkage studies are presented in Table 4. Linkage studies revealed that hard threshing and dicoccum grain type are closely linked in both straight and reciprocal crosses with crossover value 4.82% and 6.43% respectively. Thus on screening large population it is possible to get free threshing dicoccum. It can be concluded that the cross between FT, NFT and reciprocal revealed monogenic dominant control for dicoccum grain type and non free threshing habit. Close linkage was noted for these characters suggesting population sizes of the breeding materials should be increased to improve the chances of selecting FT desirable plants in the breeding programme.

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