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Exploitation of recombinational variability for yield and free threshability traits using promising mutant lines in emmer wheat (*Triticum dicoccum* (Schrank) Schuebler)

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Abstract
An investigation was carried involving two advanced mutant lines of *diccocum* wheat DDK 50440, DDK 50487 and an elite *dicoccum* variety NP 200. The crosses DDK 50440 X DDK 50487 and DDK 50440 X NP 200 were studied to know the amount of variability for free threshability and yield related traits. The result indicated the presence of high genetic variability coupled with important traits like grain yield per plant (g), thousand grain weight (g), number of grains per spike and free threshability (%) in both the crosses.

Keywords: Dicoccum, variability, free threshability, mutant lines, therapeutic value

1. Introduction
Dicoccum wheat commonly called as emmer wheat or hulled wheat, a tetraploid ($2n = 4x = 28$ chromosomes) wheat species. In world, dicoccum wheat is confined to only mountainous marginal land area of Italy and in India is grown only on limited acreage in Northern Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra and Gujarat.
Due to its nutritional and therapeutic value, *dicoccum* wheat is preferred by many people. In India *dicoccum* wheat is mainly used for preparation of semolina and in several conventional dishes and also in preparation of pasta and vermicelli. *Dicoccum* based wheat are more tasty and soft and have high potential of backing, parboiling, popping and also considered as a therapeutic food in management of diabetes, which is one of the threat for the human health along with that it always fetches 20-25 percent more price in the market as compared to bread wheat and durum wheat.
Dicoccum has great demand in the urban areas of central and southern India and also in Srilanka and Maldives but non availability of this wheat for consumption is often confined because of non free threshing varieties, lack of scientific technique regarding the dehulling of dicoccum wheat, value addition, reddish grain colour of wheat, although the yield potentiality of this semi-dwarf wheat is comparable with *Triticum aestivum* L, and *Triticum durum*. Dehulling in emmer wheat is laborious process and involves additional expense. However, only 70 percent grain recovery is possible on threshing because of fragile rachis and non free threshing kernels, which make harvesting and threshing of dicoccum wheat difficult, time consuming and expensive because of hulled grains. The hulled character is the result of two differences in structure of spike, the semi brittle joints between the rachis internodes and the toughed glumes because of presence of q gene (Kristin *et al.*, 2006) [1]. Keber and Rowland (1974) [2] reported that recessive alleles tg as well as Q factor must be present for the expression of free threshing character in hexaploid wheat. Thus, the possibility to obtain free threshing forms of *T. dicoccum* should make its cultivation economically viable. The present study is to know amount of variability present in the crosses developed using advanced mutant lines for free threshability and yield related traits which gives us an opportunity to select best lines for further breeding programme.

2. Material and Methods
Initially, the mutant lines were generated and evaluated for free threshability and other agronomic traits at All India Coordinated wheat improvement project, Main Agricultural Research Station (MARS), University of Agricultural Sciences, Dharwad.

These mutant lines were used for developing the crosses. Among different crosses generated, two dicoccum free threshable lines with non free threshable variety NP 200 were crossed in half diallel manner to generate F_1s during *rabi* 2020-2021 at wheat improvement project, MARS, UAS, Dharwad. The F_1 seeds are collected from the earlier season were used to generate F_2's by confirming the true F_1's based on ear head morphological characters. During *rabi* 2021-22, nearly 300 F_2 plants of two crosses were evaluated in Randomized Block Design (RDB) of 1m bed length. The recommended agronomic practice was followed during the crop growth period. The crop was grown under irrigated condition. Five random plants of P_1, P_2 and all the individuals of F_2's were numbered and tagged. The observations were recorded on these plants and data used for the statistical analysis. The observations were recorded on days to 50 percent flowering, days to maturity, plant height (cm), number of tillers per plant, spike length (cm), number of spikelets per spike, number of grains per spike, grain yield per plant (g), thousand grain weight (g), spike density (cm) and free threshability (%).

2.1 Statistical analysis

Genotypic and phenotypic variance, genotypic and phenotypic coefficient of variation (Burton and Devane, 1953) [3], heritability (Hanson, 1959) [4], genetic advance (GA, Robinson *et al.* 1949) [5] and genetic advance as percent of mean (GAM, Johnson *et al.* 1955) [6] were analysed for yield and free threshability characters of *dicoccum* wheat.

Table 1: List of parents and their special characters used in the present study

S.No	Line	Pedigree	Characters
1	DDK50440	DDK1025/200GY/SSD7	Medium free threshable, amber color seed and very hard glume
7	DDK50487	DDK1025/HD4502/EMS 0.2%/BULK 26	Free threshable, seed of durum wheat, soft glume, dicoccum ear head
8	NP-200	Selection of local Rishi Valley	Non free threshable dicoccum wheat

3. Result and Discussion

Genetic variability analysis of segregating generations of dicoccum wheat *i.e.*, DDK 50440 X DDK 50487 and DDK 50440 X NP showed significant variability for all the characters under study evident by significance of "F" test at p (<0.01).

Mean values for days to 50 percent flowering, days to maturity and plant height had lower values in F_2 when compared parents in both the cross so these lines can be used for development of early maturing and lines with reduced plant height which will reduce the problem of lodging in *dicoccum* wheat. There was no significant difference among the parents and F_2 generations of both crosses with respect to number of tillers per plant, spike length, number of spikelets per spike, spike density and free threshability. Mean of grain yield was higher in F_2 lines than parents in both the crosses where in, thousand grain weight had recorded higher mean in DDK 50440 X NP 200 which indicates that these lines can be best utilized for the development of thousand grain weight. Comparing to the mean value of two different crosses, DDK 50440 X DDK 50487 recorded higher mean value for free threshability than DDK 50440 X NP 200 in which parents involved in hybridization were non free threshable. The lines derived from this crosses can be used for development of free threshable lines in dicoccum.

Table 2: Mean performance of parents involved in present study

Characters	DDK 50440	DDK 50487	NP 200
Days to 50% flowering	50.00	50.00	56.00
Days to maturity	90.00	115.00	120.00
Plant height (cm)	109.40	97.10	92.10
No. of tillers/plant	25.60	21.50	22.10
Spike length (cm)	9.35	9.87	8.10
No. of spikelets/spike	21.10	23.26	21.45
No. of grains/spike	50.40	64.00	65.10
Grain yield/plant (g)	27.70	39.50	23.45
Thousand grain weight (g)	48.41	41.20	39.81
Spike density (cm)	2.05	1.94	2.31
Free threshability (%)	76.00	94.50	00.00

3.1 Genetic variability parameters, heritability and genetic advance as percent of mean:

The advanced mutant lines of *dicoccum* and their progenies recorded wide range of variability for all the characters under study. Presence of wide range of variability provides scope for practicing selection and identification of desired and superior genotypes further improvement. The heritable portion of overall observed variation can be ascertained by studying the components of variation such as coefficient of variation of genotypic and phenotypic variability, heritability and predicted genetic advance.

For all the characters under consideration, the phenotypic coefficient of variation was greater than genotypic coefficient of variation. The gap between phenotypic coefficient of variation and genotypic coefficient of variation was less which suggests that there is less effect of environment in inheritance of these traits. These findings agree with Dave *et al.* (2021) [3] Malbhage *et al.* (2020) [4] and Manik *et al.* (2020) [5].

Among two different crosses studied, the cross DDK 50440 X DDK 50487 recorded high genotypic and phenotypic coefficient of variation for grain yield per plant and free threshability because the parents involved in hybridization were highly contrasting for free threshability and yield related traits where in, DDK 50440 was medium free threshable with hard glumes and DDK 50487 was completely free threshable with soft glumes and had recorded overall mean of 72.26 g of grain yield which is higher than the other cross used in this study which indicates that this cross had more transgressive segregants than other cross and hence these cross can be used for development of free threshable dicoccum lines. These results are in line with Sharma *et al*. 2022 [10], Alemu *et al*. 2020 [7] and Khan *et al*. 2020 [11]

The cross DDK 50440 X NP 200 had high phenotypic and genotypic coefficient of variation for number of grains per spike and thousand grain weight, so the better transgressive segregants can be selected indirectly to improve the yield. The yield related traits like number of tillers per plant, number of spikelets per spike and spike length recorded no significant differences among the F_2 generation of both crosses. These results are in line with Sharma *et al*. 2022 [10], Dave *et al*. 2021 [7] and Khan *et al*. 2020 [11].

A high heritability coupled with high genetic as percent of mean with an expected high phenotypic coefficient of variation and high genetic coefficient of variation coupled with high genetic advance as percent mean was observed for number of tillers per plant, spike length, number of spikelets per spike, number of grains per spike, grain yield per plant, thousand grain weight and free threshability in both the crosses. Good amount of genetic variability observed among the genotypes for this trait and selection can be effective for different breeding programme (Sharma *et al*. 2022 [10]; Alemu *et al*. 2020 [12]). High GCV with high genetic gain indicating presence of additive gene effects in expression of these traits (Dashora *et al*. 2020 [13]).

Table 3: Estimation of variability parameters for different characters in segregating generation (F_2) of advanced mutant lines of the *dicoccum* cross DDK 50440 X DDK 50487

Character	Mean	Range		PCV (%)	GCV (%)	h^2 (bs)	GA (%)	GAM (%)
		Min	Max					
Days to 50% flowering	47.28	38.00	60.00	9.98	8.87	78.20	7.76	16.41
Days to maturity	102.43	80.00	130.00	9.98	8.76	95.36	18.36	17.92
Plant height (cm)	103.89	75.00	130.00	10.05	9.70	93.07	20.36	19.60
No. of tillers/plant	21.98	10.00	37.00	22.83	20.40	79.85	8.28	37.69
Spike length (cm)	9.56	6.10	13.70	20.25	18.76	85.86	3.42	35.83
No. of spikelets/spike	19.98	13.00	29.00	21.62	19.71	83.17	7.47	37.39
No. of grains/spike	47.57	26.00	69.00	22.08	20.03	82.28	16.97	35.68
Grain yield/plant (g)	36.63	18.40	51.10	24.42	21.22	75.52	13.91	37.98
Thousand grain weight (g)	46.69	21.67	74.08	20.34	17.94	77.82	15.20	32.57
Spike density (cm)	2.89	1.05	4.21	20.29	17.76	76.66	0.08	29.95
Free threshability (%)	75.26	0.00	100.00	22.77	20.65	82.23	28.34	37.66

Table 4: Estimation of variability parameters for different characters in segregating generation (F_2) of advanced mutant lines of the *dicoccum* cross DDK 50440 X NP 200

Character	Mean	Range		PCV (%)	GCV (%)	h^2 (bs)	GA (%)	GAM (%)
		Min	Max					
Days to 50% flowering	51.27	35.00	68.00	13.80	12.19	77.96	11.36	22.17
Days to maturity	96.95	65.00	150.00	17.35	16.61	91.51	31.71	32.71
Plant height (cm)	110.17	76.50	135.60	15.24	14.22	86.87	30.05	27.27
No. of tillers/plant	21.95	12.00	31.00	23.67	22.04	89.59	9.58	43.68
Spike length (cm)	9.67	6.30	13.30	19.17	18.08	88.95	3.39	35.13
No. of spikelets/spike	21.63	12.00	29.00	19.80	17.89	81.68	7.20	33.32
No. of grains/spike	53.89	25.00	68.00	16.59	15.58	88.19	16.24	30.15
Grain yield/plant (g)	32.42	12.70	57.50	21.80	19.50	80.00	11.65	35.94
Thousand grain weight (g)	53.37	23.30	78.25	23.76	22.21	87.39	22.83	42.77
Spike density (cm)	2.71	0.95	4.65	22.41	19.49	75.67	0.94	34.93
Free threshability (%)	68.11	0.00	100.00	24.05	22.42	86.88	34.92	43.05

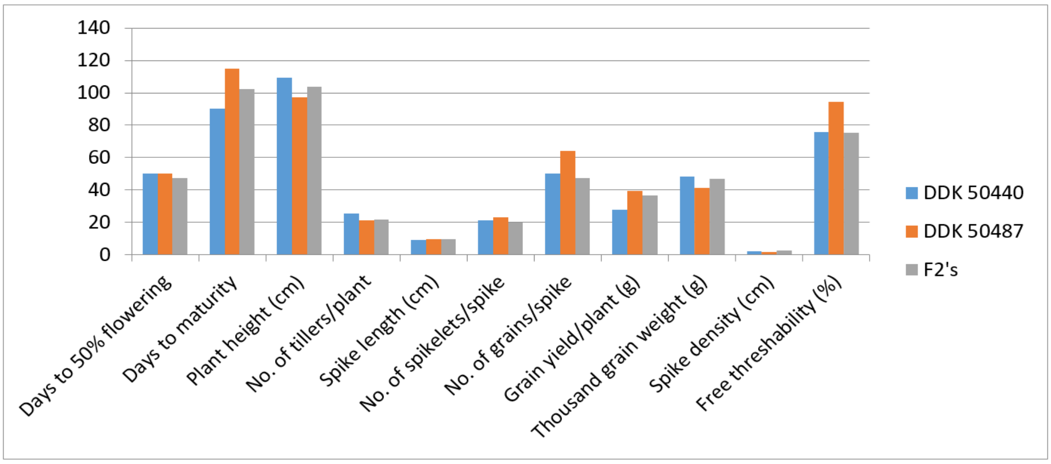

Fig 1: Mean values for differential characters in P_1, P_2 and F_2's of the cross DDK 50440 X DDK 50487

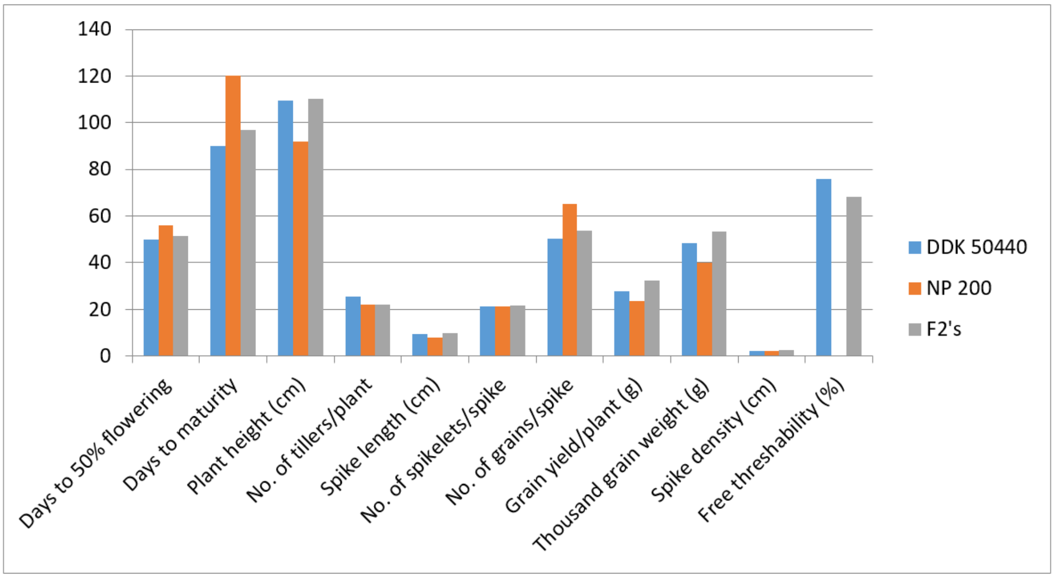

Fig 2: Mean values for differential characters in P_1, P_2 and F_2's of the cross DDK 50440 X NP 200

4. Conclusion

The wide range of variability among the two different crosses, indicate the presence of sufficient variability in all the characters studied. The manipulation by the environment was scanty in expression of these traits which was marked by the slight difference in the phenotypic coefficient of variation and genotypic coefficient of variation. High heritability coupled with high genetic advance as per mean indicate the predominance of additive gene action and they are simply inherited (Kulkarni *et al.* 2017) [10] and a simple selection schemes will be sufficient to fetch the genetic enhancement in desired direction for free threshability and other yield and yield related traits. Among two different crosses, DDK 50440 X DDK 50487 cross found to be promising with respect to grain yield per plant and free threshability hence these lines can be used for development of free threshable genotypes in dicoccum wheat.

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