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Research Article

Assessment of genetic variation and trait inter-relationship in landraces and elite cultivars of durum wheat (*Triticum durum* Desf.)

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Abstract

Eighteen landraces and elite cultivars of durum wheat were evaluated during Rabi 2020-21 to estimate genetic variability and trait inter-relationship for ten yield and yield contributing traits. Analysis of variance revealed the presence of significant variation among accessions for all measured traits. Correlation analysis indicated that fertile spikelet, grain number per spike, spike length and biological yield have a significant positive correlation with seed yield. Plant height, 100 seed weight and grains/spike appeared to be important traits based on their direct and indirect effect towards seed yield. Regression analysis revealed an adoptive regression coefficient for biological yield per plant while harvest index, spike length, total kernel weight, fertile spikelets, plant height, days to maturity, and 50% flowering revealed a regression coefficient which is non-adoptive. Local landraces performed well in comparison to elite cultivars in terms of yield per unit area. The estimated variations among genotypes in studied traits are due to genetic differences of genotypes and selection would be beneficial. Therefore, while exercising selection in wheat, characters like plant height, 100 seed weight and biological yield per plant must be given preference.

Keywords: Correlation; Durum wheat; Genetic variability; Path analysis; Regression analysis.

1. Introduction

Wheat is an important cereal crop, cultivated on 215.9 million hectares, with 765.8 million tons of production globally. Durum wheat (*Triticum durum* Desf., 2n = 4x= 28, AABB) belongs to the family Poaceae with 7 basic sets of chromosomes. It is identified by different names like hard wheat, pasta, and macaroni wheat. Durum is the second most cultivated species in the world as well as in India after bread wheat (*T. aestivum* L.). The durum grains are very hard, comparatively large in size, vitreous, and yellow-amber. Durum wheat grains contain a good amount of starch, lipids and protein content found more than bread wheat. Globally durum wheat is cultivated under 6.2% of the total wheat area which is about 13.5 million hectares with an annual production of 33.8 million tons. Out of the total global production, the Mediterranean region acquires almost 50% share both in terms of area and production (Martinez-Moreno *et al.,* 2022). The world durum wheat area and production are concentrated in Mediterranean Europe, West Asia, North Africa, Canada, India, and Mexico. Durum wheat is spring wheat; apart from that winter durum is also grown to a limited extent (Kadkol *et al.,* 2023).

The degree of genetic variability contained in a population is critical to the success of any plant breeding program (Kandel *et al.,* 2018). Crop plants are becoming susceptible to major as well as minor diseases and are severely affected by adverse climatic conditions which may be attributed to the reduction in genetic variability (Aremu, 2012). With the cultivation of elite wheat varieties, the genetic variability of locally well-adapted traditional durum wheat is adversely declining (Royo *et al.,* 2009). A narrow gene pool in durum wheat indicates an enhanced risk of vulnerability to diseases and pests (Frankel *et al.,* 1995). A genetic variance may occur either due to geographic separation or the presence of a genetic crossability barrier (Singh, 1985). To identify the desired material for plant breeding the knowledge of patterns and degree of diversity within and between the populations is very crucial. It is well known that crossing between two diverse parents results in maximum heterosis, favourable genetic recombination and segregation in F2 and successive progenies (Singh, 1985: Asmamaw et al., 2019). Grain yield is a complex trait and depends upon several variable components and their interaction. Breeders must focus on channeling new genetic variability for important traits into the genetic pool, which will help develop improved climate-resilient durum wheat genotypes.

The correlation coefficient is useful for determining the relationship between distinct traits. Correlation can be used to select a particular character and avoid traits associated with undesirable changes (Singh and Chaudhary, 1977). According to Ali and Shakor (2012) and Anwar *et al.* (2009) an assessment of the association between yield and its component attributes alone is not sufficient to predict grain yield. Path coefficient analysis gives more information than correlation coefficient analysis since it determines the direct and indirect impact of a specific character on grain production (Arshad *et al.,* 2006). Therefore, the present investigation attempts to study the nature and magnitude of genetic variability present in the local landraces and elite durum wheat cultivars, which is essential for the selection of parents in hybridization for recombinant breeding.

2. Material and Methods

The present investigation was conducted at the Experimental Research Farm of Banda University of Agriculture & Technology, Banda, Uttar Pradesh, India. Out of eighteen genotypes, eleven landraces were collected from the different sites of the Bundelkhand region and the remaining seven varieties were collected from IARI, Regional Research Station, Indore MP (Table 1). The experiment was laid out by following a Randomized Complete Block Design (RBD) with two replications during 2020-21. Each genotype was planted in a plot size of 4 rows of 4m keeping 20 cm row-to-row spacing. Sowing was done by hand using a manual furrow opener. The local recommended agronomic package and practices were followed to raise a healthy wheat crop. To avoid the border effect, the experimental plot was surrounded peripherally by the non-experimental genotype. Phenotypic data were recorded from five randomly selected plants from each plot for different traits viz. 50% flowering (FW), plant height (PH), seed weight (SW), number of grains per spikelet (GS), spike length (SL), harvest index (HI), and seed yield (SY). Mean data were used for calculating descriptive statistics. The genetic variability coefficients viz., genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were calculated.

$$\text{GCV (\%)} = \frac{\sqrt{\sigma^2 g}}{\bar{x}} = \frac{\sqrt{\sigma^2 g}}{\bar{x}} \text{x } 100$$

Where, $\sigma^2 g \sigma^2 g$ = Genotypic variance, $\bar{X} = \bar{X}$ = General mean

$$\text{PCV (\%)} = \frac{\sqrt{\sigma^2 p}}{\bar{x}} = \frac{\sqrt{\sigma^2 p}}{\bar{x}} \text{x } 100$$

Where, $\sigma^2 p \sigma^2 p$ = Phenotypic variance, $\bar{X} = \bar{X}$ = General mean

The correlation coefficient between components and traits plays a key role in the selection of suitable breeding material. Estimation of the degree and direction of correlation was done according to Robinson and Comstock (1950) and Path Coefficient analysis was carried out according to Dewey and Lu (1959).

3. Results and Discussion

3.1 Genetic Variability

The analysis of variance (ANOVA) revealed highly significant differences for all major traits, indicating the presence of high amount of genetic variability among all the genotypes. (Table 2).

Table 1: Entry name, and source of collection of different durum wheat genotypes

S.No.	Entry name	Source of collection
1	Local-1	Desi Kathiya Hamirpur Local
2	Local-2	Jalaun Local
3	Local-3	Khatiya
4	Local-4	Jalaun Local
5	HI-8627	HI-8627
6	HI-8713	HI-8713
7	HI-8737	HI-8737
8	HI-8759	HI-8759
9	HI-8777	HI-8777
10	HI-8802	HI-8802
11	HI-8805	HI-8805
12	Local 5	KathiyaSurali Banda Local
13	Local 6	KVK Jalaun
14	Local 7	KVK Lalitpur Local
15	Local 8	KVK Mahoba Kathiya
16	Local 9	Luktara Banda Arvind Pandey Local
17	Local 10	Luktara Banda KVK Shyam Babu Local
18	Local 11	Suroli Banda

Table 2: Analysis of variance for yield and its contributing traits in durum wheat

S.No	Source of Variation	Replication (Df=1)	Genotype (Df=17)	Residuals (Df=17)
1	FW	1.78	30.70***	2.31
2	DM	7.11	21.95**	6.64
3	PH	1.43	574.39***	5.52
4	FS	1.63	2.11*	0.76
5	TKW	0.04	0.216***	0.02
6	GS	0.89	39.77**	7.74
7	SL	0.83	2.49**	0.35
8	BY	1.24	2.49***	0.43
9	HI	73.33	45.96*	17.07
10	SY	17.00	1029455***	33951

*, ** and* ** significant at 0.05, 0.01 and 0.001% levels of significance

FW: Days to 50% flowering; DM: Days to Maturity; PH: Plant Height (cm); FS: Fertile spikelets; TKW: Total kernel weight; GS: Grain Number\Spike; SL: Spike length; BY: Biological Yield(kg)/Plot; HI: Harvest Index; SY: Seed Yield

Table 3: Genetic Variability Parameters for yield and its contributing traits in durum wheat

S. No.	Genetic parameter\Variables	FW	DM	PH	FS	TKW	GS	SL	BY	HI	SY
1	Maximum	85.00	118.00	135.50	11.00	4.64	51.00	10.50	6.68	58.44	5354.17
2	Minimum	70.00	104.00	80.33	5.00	3.31	27.00	6.00	2.44	29.27	2266.67
3	Mean	77.50	111.72	104.09	8.75	3.98	40.95	7.87	4.40	39.23	3656.13
4	Standard Error of Mean (SEm)	1.07	1.82	1.66	0.62	0.09	1.97	0.42	0.47	2.92	130.29
7	Environmental Variance	2.31	6.64	5.52	0.76	0.02	7.74	0.35	0.43	17.07	33950.67
8	Genotypic Variance	14.20	7.66	284.44	0.67	0.10	16.02	1.07	1.03	14.44	497751.98
9	Phenotypic Variance	16.51	14.30	289.96	1.43	0.12	23.76	1.42	1.46	31.52	531702.65
10	Environmental Coefficient of Variance	1.96	2.31	2.26	9.94	3.25	6.79	7.50	14.96	10.53	5.04
11	Genotypic Coefficient of Variance	4.86	2.48	16.20	9.39	7.93	9.77	13.14	23.04	9.69	19.30
12	Phenotypic Coefficient of Variance	5.24	3.38	16.36	13.67	8.57	11.90	15.13	27.47	14.31	19.94
13	Heritability (Broad Sense)	0.86	0.54	0.98	0.47	0.86	0.67	0.75	0.70	0.46	0.94
14	Genetic Advance	7.20	4.17	34.41	1.16	0.60	6.77	1.85	1.75	5.30	1406.20
15	Genetic Advance as a percentage of mean	9.29	3.73	33.06	13.28	15.12	16.53	23.50	39.80	13.51	38.46

Table 4: Phenotypic (below diagonal) & Genotypic (above diagonal) correlations of durum wheat genotypes

	FW	DM	PH	FS	TKW	GS	SL	BY	HI	SY
FW		0.1285 NS	0.2429 NS	-0.4549 NS	-0.6384 **	-0.5199 *	-0.2873 NS	-0.4325 NS	0.0563 NS	-0.383 NS
DM	0.1157 NS		0.2032 NS	-0.2404 NS	-0.0897 NS	-0.5832 *	0.0022 NS	0.0293 NS	0.0243 NS	0.0707 NS
PH	0.2275 NS	0.1419 NS		0.6765 **	-0.3189 NS	0.0557 NS	0.5819 *	0.4999 *	-0.4354 NS	0.42 NS
FS	-0.3517 *	-0.1935 NS	0.462 **		0.1625 NS	0.5611 *	1.1433 **	0.8211 **	-0.6248 **	0.7015 **
TKW	-0.5546 **	-0.1383 NS	-0.2921 NS	0.1613 NS		0.5476 *	0.1205 NS	0.3478 NS	0.0651 NS	0.4445 NS
GS	-0.3318 *	-0.2601 NS	0.0452 NS	0.2976 NS	0.3709 *		0.4548 NS	0.5774 *	0.1324 NS	0.7461 **
SL	-0.2687 NS	-0.057 NS	0.5293 **	0.6488 **	0.0708 NS	0.3611 *		1.0057 **	-0.9281 **	0.7581 **
BY	-0.3392 *	-0.0269 NS	0.4418 **	0.6404 **	0.303 NS	0.4067 *	0.811 **		-0.5864 *	0.9017 **
HI	0.025 NS	-0.0581 NS	-0.3226 NS	-0.6189 **	-0.0648 NS	0.0823 NS	-0.4941 **	-0.5967 **		-0.2163 NS
SY	-0.3534 *	-0.0067 NS	0.4026 *	0.4919 **	0.3935 *	0.6029 **	0.6775 **	0.8298 **	-0.1607 NS	

FW: Days to 50% flowering; DM: Days to Maturity; PH: Plant Height (cm); FS: Fertile spikelets; TKW: Total kernel weight; GS: Grain Number\Spike; SL: Spike length; BY: Biological Yield(kg)/Plot; HI: Harvest Index; SY: Seed Yield

A wide range of genetic variability for measured traits was observed in durum wheat genotypes. As in Table 3, The GCV was found higher for BY (23.04) followed by SY (19.30), PH (16.20), SL (13.14), GS (9.77), HI (9.69), and FS (9.39). The traits DM (2.48), FW (4.86), and TKW (7.93) showed low GCV. The PCV was found higher for the BY (27.47) followed by SY (19.94), PH (16.36), and SL (15.13) whereas, it was recorded lower for the DM (3.38), FW (5.24) TKW (8.57). The PCV was higher than the GCV for almost all the traits. The present study revealed high heritability for PH (0.98), SY (0.94), FW (0.86) and TKW (0.86) while high genetic advance was indicated for SY (1406.20) PH (34.41), FW (7.20) and GS (6.77).

3.2 Correlation coefficients

The correlation coefficient analysis between seed yield and yield contributing characters was reported to be highly positive significant. As per Table 4, The results show that the trait SY was significantly positively correlated with BY (rp=0.83**), SL (rp=0.68**), GS (rp=0.60**), and FS (rp=0.49**). The least significant correlation with PH (rp=0.40*) and TKW (rp=0.39*). A negative significant correlation was shown with FW (rp=-0.35*) and a negatively non-significant correlation with DM (rp=-0.01) and HI (rp=-0.16). The genotypic correlation of seed yield was found highly significant and positively correlated with BY (rg=0.90**), SL (rg=0.76**), GS (rg=0.75**), and FS (rg=0.70**). A non-significant correlation was shown with DM (rg=0.07), PH (0.42), and TKW (0.44). HI (-0.22) and FW (-0.38) showed a negative non-significant correlation with seed yield. A positive correlation was reported for most of the traits that are related to seed yield. The magnitude of the genotypic correlation was found higher for most of the traits in comparison to phenotypic values showing the presence of inherent association among traits.

3.3 Path coefficient analysis

The path coefficient analysis was done with all characters to estimate the direct and indirect effects of nine characters on seed yield based on the phenotypic and genotypic correlation coefficient. The genotypic path exerts a positive direct effect for the traits PH (0.44), SW (0.24) & GS (0.19) which indicates direct selection based on these traits may be effective. Negative direct effects of traits on seed yield include FW (-1.69), SL (-0.63) and HI (-1.72). The direct negative effects of these traits on declining seed yield were also reported by Bhutta *et al.* (2005) and Sabit *et al.* (2017).

Highly positive direct phenotypic effects on seed yield were shown by SW (0.39), and PH (0.22), followed by SL (0.18). High values of direct effects indicate that the good relationship and direct selection for these traits would be effective for improving seed yield. On the other side, the negative and unfavorable direct effect on seed yield was shown by FW (-0.42), GS (-0.19) and HI (-0.27). Seed weight put higher negative indirect effects on seed yield via FW (-0.20), PH (-0.13) and SL (-0.05) and a positive indirect effect via GS (0.05) and HI (0.17), Subhaschandra *et al.* (2009) also found similar results. Plant height exerts a positive but indirect effect on seed yield via FW (0.02) and SL (0.13). Plant height is the plant growth determining character which ultimately determines seed yield in durum wheat, while negative indirect effects of seed yield through SW (-0.07), GS (-0.04) and HI (-0.13) (Ali *et al.,* 2008).

3.4 Regression coefficient analysis for yield component

Regression analysis was undertaken to find out the relationship between a dependent variable on other independent variables, The regression coefficient (R2) is adaptable for BY and SY (67.1) and it is unadaptable for all the other traits with seed yield such as HI (2.41), SL (46.2), GS (36.2), TKW (15.3), FS (27), PH (16.2), DM (0.004) and FW (12.4) (Ahmadizadeh *et al.,* 2011: Zarei *et al.,* 2011).

3.5 Yield performance

Yield being the most prominent factor of any crop is a quantitative trait depending on all morpho-physiological characters. Improvement in yield is the main objective of any breeding program. Landraces are reservoirs of diversity and in the present investigation, the performance of local landraces was much better than the elite cultivars (Figure 2). The best five genotypes identified for each trait were identified and are presented in Table 7. The average performance of the elite cultivars was 3049 kg/ha in comparison to that, Local landraces performed with an average of 4142 kg/ha. The best performing elite cultivars were HI-8802 (3478 kg/ha), HI-8713 (3454 kg/ha), HI-8627 (3211 kg/ha) and in the locals, Local 6 (5130 kg/ha), Local 1 (4466 kg/ha), Local 7 (4441 kg/ha) performed best.

Table 5: Estimation of genotypic direct (bold diagonal) and indirect (normal diagonal) effects of different seed yield of durum, wheat genotypes

	FW	PH	SW	GS	SL	HI
FW	**-1.69**	0.15	-0.18	-0.01	0.15	0.96
PH	-0.59	**0.44**	-0.11	-0.20	-0.42	1.31
SW	1.30	-0.20	**0.24**	0.02	0.04	-0.90
GS	0.11	-0.45	0.02	**0.19**	0.94	-2.19
SL	0.42	0.29	-0.01	-0.29	**-0.63**	1.21
HI	0.94	-0.33	0.12	0.24	0.44	**-1.72**

FW: Days to 50% flowering; PH: Plant Height (cm); SW: Seed weight; GS: Grain Number\Spike; SL: Spike length; HI: Harvest index

Table 6: Estimation of phenotypic direct (bold diagonal) and indirect (normal diagonal) effects of different seed yield of durum, wheat genotypes.

	FW	PH	SW	GS	SL	HI
FW	**-0.418**	0.024	-0.202	-0.015	-0.033	0.126
PH	-0.046	**0.216**	-0.131	0.035	0.109	0.166
SW	0.217	-0.073	**0.387**	-0.024	-0.023	-0.118
GS	-0.033	-0.039	0.049	**-0.195**	-0.083	-0.077
SL	0.074	0.128	-0.048	0.087	**0.184**	0.140
HI	0.196	-0.133	0.171	-0.056	-0.096	**-0.270**

FW: Days to 50% flowering; PH: Plant Height (cm); SW: Seed weight; GS: Grain Number\Spike; SL: Spike length; HI: Harvest Index

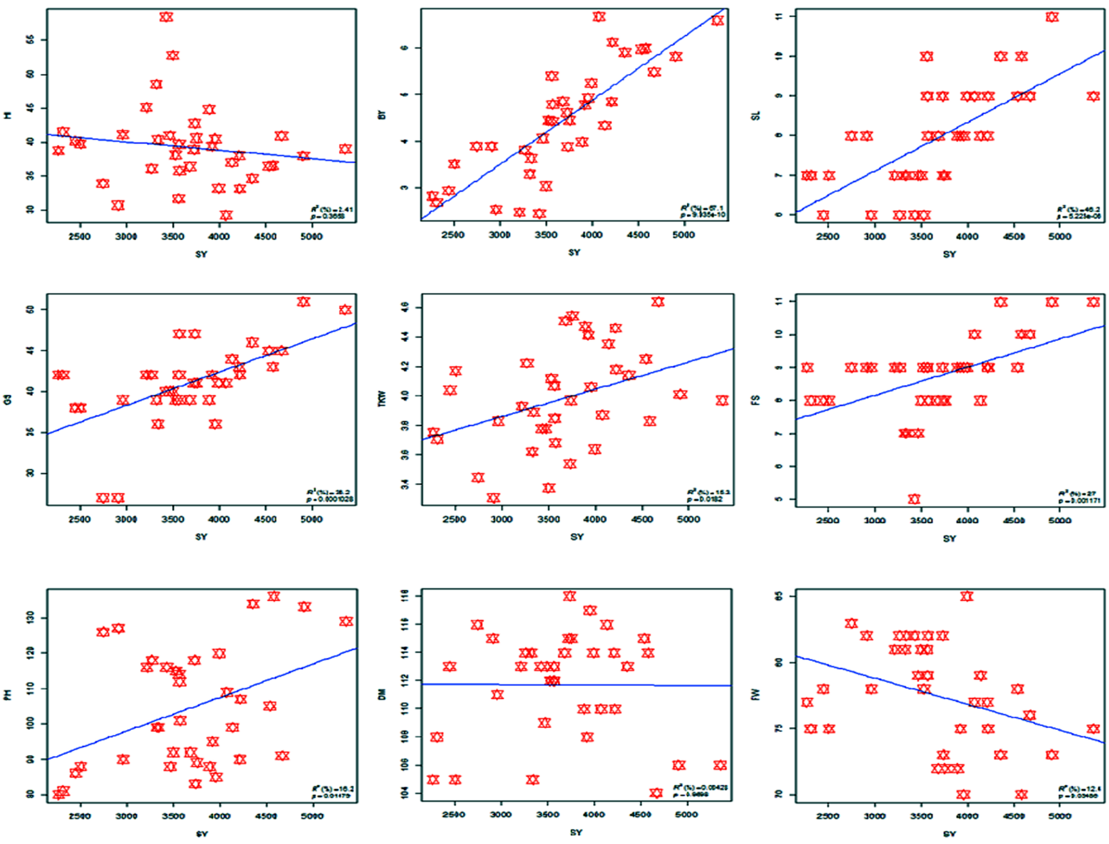

Figure 1. The regression coefficient of seed yield with contributing traits.

Table 7: Best five genotypes for yield and contributing traits.

S.No.	Traits	Name of the genotype
1	50% Flowering	Local-1 (72), Local-3 (72), Local-2 (72), Local-4 (74), Local-6 (74)
2	Days to Maturity	Local-6 (106), HI-8759 (107), HI-8713 (109), Local-4 (109), Local-7 (109)
3	Plant Height (cm)	HI-8759 (81), Local-3 (84), HI-8737 (87), HI-8777 (89), Local-7 (90)
4	Fertile Spikelet	Local-6 (11), Local-1 (11), Local-10 (10), HI-8805 (9), Local-5 (9)
5	Total Kernel Weight (gm)	Local-7 (4.55), Local-2 (4.53), Local-4 (4.44), Local-8 (4.30), HI-8737 (4.11)
6	Grain/Spikelets	Local-6 (51), Local-8 (45), Local-1 (44), Local-7 (44), HI-8805 (42)
7	Spike Length (cm)	Local-6 (10), Local-1 (10), Local-5 (9), Local-7 (9), Local-9 (9)
8	Biological Yield (kg/ha)	Local-10 (6400), Local-6 (6210), Local-1 (5955), Local-7 (5160), Local-8 (5160)
9	Harvest Index	HI-8627 (50.64), HI-8802 (48.29), Local-4 (42.05), Local-3 (41.59), HI-8777 (41.05)
10	Seed Yield (kg/ha)	Local-6 (5130), Local-1 (4466), Local-7 (4441), Local-8 (4338), Local-10 (4145)

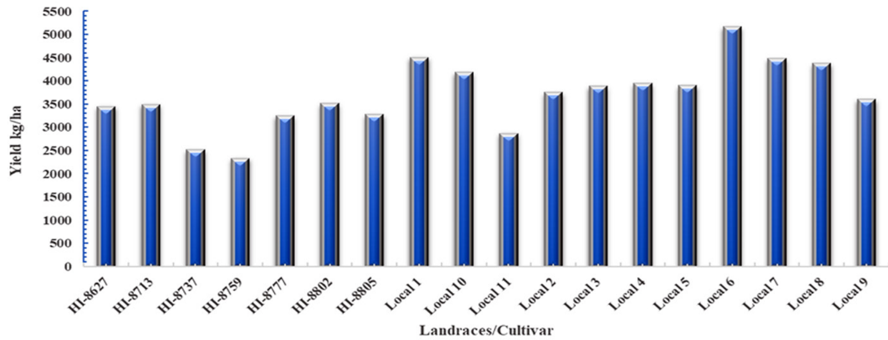

Fig 2: Yield wise (kg/ha) Performance of local landraces and elite cultivar.

Conclusion

The present study revealed high heritability and genetic advance for plant height, indicating the importance of plant height for direct selection. DM, GS, SL and BY showed high heritability coupled with moderate genetic advance, revealing moderate expected genetic gain via selection under environments. The presence of a considerable amount of genetic variation among durum wheat landraces for all traits provides an opportunity for the selection of these valuable traits. Correlation coefficient and path coefficient analysis revealed that plant height and seed weight are important selection criteria because they have a high direct and indirect effect on other traits on seed yield. Plant height, seed weight and grains per spike showed important characteristics toward seed yield and most adoptive regression coefficients appeared for biological yield per plant. These traits can be used in breeding programmes to develop high-yielding genotypes.

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Author contributions

The conceptualization of research (H.K., M.K.); Designing of the experiments (H.K.); Execution of field experiments and data collection (S.S., H.K.); Analysis of data and interpretation (H.K., S.S.); writing–original draft preparation, S.S. and D.S.; writing–review and editing, V.G., S.K., H.K.; Preparation of the manuscript (V.G., H.K.).

Conflict of interest

No

Declaration

The authors declare no conflict of interest.

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