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Short Communication

Pursuing wheat yield maximization in north-western plains of India

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Bread wheat (*Triticum aestivum* L.) is the most important winter cereal in of India. North Western Plains Zone (NWPZ) comprising Punjab, Haryana, Delhi, Rajasthan (except Kota and Udaipur divisions) and Western UP (except Jhansi division), parts of J&K (Jammu and Kathua distt.) and parts of HP (Una dist. and Paonta valley) and Tarai region of Uttaranchal plays important role in the national food security as wheat procurement is highest amongst all five wheat zones of the country (FCI, 2022). Wheat productivity is also highest in this zone for which it has earned the title "wheat basket of India" (Khan *et al.,* 2022). In this region, which falls in the Mega Environment 1 (Rajaram *et al.,* 1993), not many efforts have been made for maximizing grain-yield output of wheat varieties. In the recent past, wheat improvement programme has taken a new initiative to harness maximum yield potential selection of input responsive genotypes suitable for early sowing combined with the application of modified crop management practices, growth regulations, etc. (ICAR-IIWBR, 2018). This approach has combined best of the resource management practices and aims to identify and release bread wheat genotypes suited for early sown high fertility conditions. In this system, growth duration is increased by early sowing (October 25 to November 5), 150% recommended doses of NPK along with 15 t/ha FYM and the trial is named as Special High Yield Potential Trial (SPL-HYPT). To keep the plant height in check for prevention of ldging, two sprays of growth regulators (height retardants) are applied in SPL-HYPT at the first node and flag leaf stage with chlormequat chloride (Lihocin) @ 0.2% + tebuconazole (Folicur 430 SC) @ 0.1%. This practice was initiated in several countries including France (Berry *et al.,* 2004), Canada (Reddekopp *et al.,* 2017), Australia (Peake *et al.,* 2020) and good results had been obtained. In this investigation, SPL-HYPT trials data has been analysed and comparison has been made with the normal timely sowing trials (NTST) in NWPZ where sowing is done during November 1-15, and the NPK dose is 150:60:40 (kg/ha). Multi-environment performance of these two types of trials conducted in NWPZ during the three year period of 2020-22 at six common test sites i.e. Delhi, Karnal, Ludhiana, Gurdaspur, Hisar and Pantnagar has been examined in this study. Six genotypes evaluated as checks in these trials were examined and the varieties were DBW 187, DBW 303, DBW 327, DBW 332, HD 3086 and WH 1270 in SPL-HYPT; and DBW 222, DBW187, HD 3086, HD 2967, WH 1005 and PBW 826 in NTST. Aim of this investigation was to ascertain advantage in yield and yield sustainability, demarcate the effective variation sources and earmark the suitable locations.

Yield advantage and the key contributing trait

Results indicated that there was 22% yield gain in comparison to NTST in HYPT genotypes (Table 1). Highest yield in these multi-environment trial was 91.5 q/ha in HYPT whereas it was restricted to just 76.9 q/ha in NTST. The yield advantage in HYPT was accrued through higher grain number and bigger grain size. Vegetative period in both the trials was almost same but a big difference in grain filling duration (GFD) indicated that the SPL-HYPT genotypes expressed better tillering. In spite of heavy grain bearing, 1000 grain weight (TGW) was higher in HYPT because grain filling duration was longer than TSW. Per day productivity in HYPT was better than NTST. It underlines that high productivity in HYPT was not because of longer crop duration only, the genotypes might also have responded well to draw an advantage in favour of grain yield.

Table 1: Overall productivity, crop expression and crop efficiency

Parameters	SPL-HYPT	NTST
Average yield (kg/ha)	71.7	58.7
Highest yield (kg/ha)	91.5	76.9
Plan height (cm)	97.3	101
TGW (g)	42.9	40.5
Grains/ m^2 ('000)	16.7	14.5
Days to heading	99.0	97.2
GFD	54.2	47.9
Days to maturity	153	145
Per day productivity (kg/ha)	46.8	40.5

In HPYT, there were two varieties namely DBW 187 and HD 3086 which were otherwise developed for timely-sown condition but were included in this trial as check so as relative advantage in the varieties bred specifically for early-sown conditions could be worked out (Khan *et al.,* 2020). Average yield of these two varieties at the same locations and in same crop years was 17 % higher in HYPT in comparison to NTST (HYPT: 67.8 q/ha; NTST: 57.9 q/ha). The other four varieties i.e. DBW 303, DBW 372, DBW 332, and WH 1270 developed for such conditions definitely had better yielding ability in comparison to DBW 187 and HD 3086 (Table 2). When plant characteristics were examined between these two groups of varieties, it was observed that there was no difference in plant height, days to heading and maturity duration. Difference in TGW was also marginal but big difference lied in grain number/m^2 which increased from 15.9 to 17.1 thousand grains.

Table 2: Difference between the timely-sown and the varieties specifically developed for early-sown conditions

Parameters	DBW 187 and HD 3086	DBW303, DBW 327, DBW 332 and WH 1270
Mean yield (q/ha)	67.8	73.7
Day to heading	99.0	99.0
Days to maturity	153	153
Plant height (cm)	97.5	97.2
TGW (g)	42.5	43.2
Grains/m^2 ('000)	15.9	17.1

Yield and sustainability differences in genotype

Majority of the varieties tested in HYPT expressed higher yield potential in comparison to NTST genotypes (Fig 1). Maximum yield in four varieties was around 9 t/ha (range: 87.8 to 91.5 q/ha). It was only HD 3086, a timely-sown genotype, where the yield potential remained below 8 t/ha. Except this variety, mean yield in other five varieties was ≥ 7 t/ha. In comparison, only three varieties namely PBW 826, DBW 222 and WH 1105 could register 6 t/ha tonnage in NTST. Besides grain yield, differences could also be noticed in yield sustainability as well. It can easily be adjudged by computing the sustainability index (SI), as defined by Singh *et al.,* (1990). SI of every genotype of HYPT group was ≥ 70 % (range: 70-78 %). In NTST, there were four varieties of match SI (≥ 70 %). Results showed that there can also be a situation in NTST when genotype like HD 2967 could express SI as low as 54 %. It clearly establishes that it is easier to harness advantage of higher yield potential under HYPT conditions.

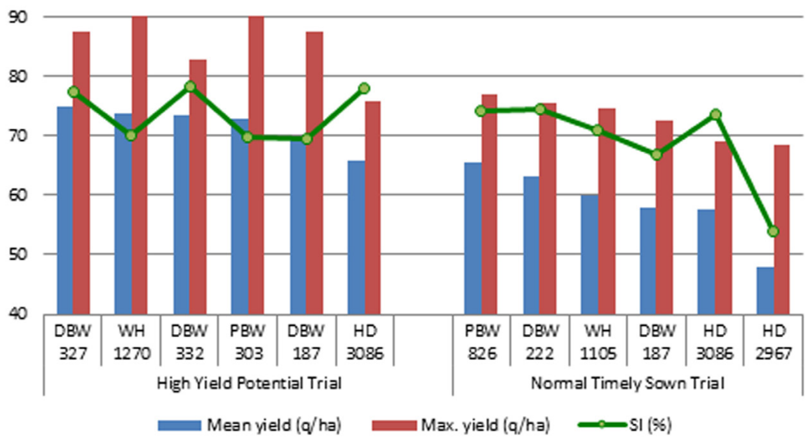

Fig 1: Contribution of variation sources in grain yield

C. Location specificity

Under multi-location testing in a mega-zone, it is quite obvious to trace location differences (*Singh et al.,* 2007) but response of the test sites can also differ under different production conditions. This investigation showed that the yield advantage in HYPT over NTST was highly significant at each location under testing (examined by *t*-test). Lowest gain was recorded at Hisar (12 %) whereas Ludhiana, Karnal and Gurdaspur harnessed yield advantage of 25-28 % (Table 3). It showed that Hisar is not a proper place to draw good advantage of early sowing and high inputs. Results also ascertained that at certain sites like Karnal, Delhi, Ludhiana and Pantnagar where mean yield in HYPT usually remains more than ≥ 7 t/ha (73-77 q/ha). Yield potential at such sites also remains ≥ 8 t/ha (82-92 q/ha). In comparison, average productivity of these sites in NTST remains around 60 to 62 q/ha and the yield potential also hangs around 75 q/ha. Location specificity can also be observed in yield sustainability. Results showed that grain yield is better sustained in SPL-HYPT. Except Gurdaspur, SI was ≥ 75 % at each location whereas it was only the Pantnagar location which could match such standards in NTST. It could also be confirmed by coefficient of variation (CV). In SPL-HYPT, maximum CV was 11% which was recorded at Karnal, Pantnagar and Gurdaspur. In NTST, every location except Pantnagar registered CV > 11 % and the most sensitive sites were Karnal and Gurdaspur.

Table 3: Location differences in yield and yield sustainability

Location	Mean yield (q/ha)		Maximum yield (q/ha)		Coefficient of variation (%)		Sustainability index (%)	
	HYPT	NTST	HYPT	NTST	HYPT	NTST	HYPT	NTST
Karnal	77.3	60.4	91.5	74.5	11.3	17.0	74.9	67.3
Delhi	76.1	60.2	85.0	76.9	6.10	18.4	84.1	63.8
Ludhiana	75.1	62.2	88.6	76.7	8.89	12.9	77.2	70.6
Pantnagar	73.5	60.7	82.1	72.4	10.6	11.1	80.1	74.5
Hisar	66.9	60.0	77.6	76.8	8.12	16.0	79.3	65.6
Gurdaspur	61.5	49.0	78.3	60.9	10.8	17.2	70.0	66.7

Data source: Annual Wheat Improvement reports of AICRPW&B (2020-22)

Across all locations of NWPZ, SI was 68.9 % in HYPT and 63.4 % in NTST. In a mega-zone, it is always better to consider yield sustainability on the basis of locations. Yield potential realized under most favorable condition of any zone can't really be replicated at all locations. Every location has its own limit for the yield maximization. If median is drawn for out of the six sites, then HYPT conditions stand far better in yield sustainability. SI median was 78.2 % in HYPT and 67.0 % in NTST. Comparison of the two production conditions on the basis of extent of yield variations also revealed that CV in HYPT (12.2 %) was lower than NTST (17.0 %).

D. Divergence in variation sources

Percent share in yield variation (calculated on the basis of sum of squares) for three main effects namely genotype, location, year and the interactions like GL, GY, LY and GLY also differed in the two trials (Fig 2). Variations caused by genotypic differences were highest in NTST whereas locations caused maximum yield variations in HYPT. It shows that genotypic differences are minimized when planting is done early whereas the site differences get magnified under such conditions. If share percentage of variation sources is divided into four groups i.e. small (6-10 %), moderate (11-20 %), high (21-30 %) and very high (>31 %), then it can be concluded that in yield variations of HYPT, there is very high impact of locations, moderate effect of genotypes and L*Y; and small impact of G*L and G*Y. In NTST; there can be high or very high impact of genotypes and L*Y, moderate effect of locations and G*L, and small impact of G*L*Y. If G*L, G*Y and G*L*Y is combined together as GE, then it can be ascertained both system express similar impact of GE (HYPT: 25.6 %. NTST: 24.3 %).

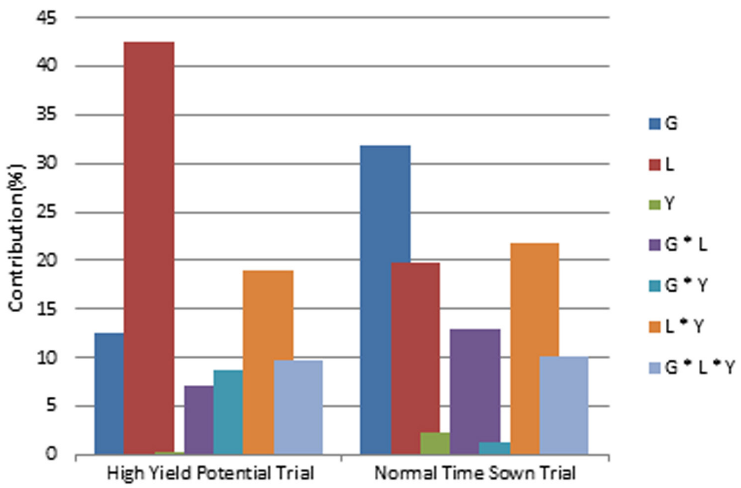

Fig 2: Contribution of variation sources in grain yield

Often the temperature may not be favourable to go for early sowing. hence, varieties carrying genes for early heat tolerance are necessary for early sowing (Kumar *et al.,* 2021). It has been estimated that early sowing wheat systems can increase Australian wheat yields by 0.54 t ha^{-1} under changing climatic conditions (Kumar *et al.,* 2018). The present study conclude that early sowing coupled with suitable genotypes amenable to the modified crop management practices can boost average wheat grain yield 1.3 tones/ha in NWPZ.

Author contributions

HK and DM conceptualized the study. DM analyzed the data. DM wrote the first draft. HK and GS edited and improved the manuscript. All the authors read the final version of the manuscript and approved for submission.

Conflict of interest

No

Declaration

The authors declare no conflict of interest.

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