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Data Descriptor

Multi-Year On-Farm Trial Data on the Performance of Long- and Short-Duration Wheat Varieties against Sowing Dates in the Eastern Indo-Gangetic Plain of India

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SOWING: Ekim

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Abstract: Sub-optimal wheat productivity in the eastern Indo-Gangetic plain of India can largely be attributed to delayed sowing and the use of short duration varieties. The second week of November is the ideal time for sowing wheat in eastern India, though farmers generally plant later. Late-sowing farmers tend to prefer short-duration varieties, leading to additional yield penalty. To validate the effect of timely sowing and the comparative performance of long- and short-duration varieties, multi-location on-farm trials were conducted continuously over five years starting from 2016–2017. Ten districts were selected to ensure that all the agro-climatic zones of the region were covered. There were five treatments of sowing windows: (T1) 1 to 10 November, (T2) 11–20 November, (T3) 21 to 30 November, (T4) 1–15 December, and (T5) 16–31 December. Varietal performance was compared in T3, T4, and T5, as short-duration varieties are normally sown after 20 November. There is asymmetry in the distribution of samples within treatments and over the years due to the allocation of fields by farmers. Altogether, the trial was conducted at 3735 sites and captured 61 variables, including yield and yield attributing traits. Findings suggested that grain yields of long-duration wheat varieties are better even under late sown scenarios.

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Keywords: wheat; sowing date; variety; India

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1. Summary

The eastern Indo-Gangetic plain is characterized by fertile alluvial soils [1] wherein rice and wheat are predominantly grown. This region has the potential to support high wheat yields if proper crop production practices are put into place [2]. There is a substantial yield gap in wheat mainly due to delayed sowing [3] and the use of late-sown varieties [4]. Over the past several years, farmers' awareness regarding the 'importance of time' in wheat sowing (sowing in the first fortnight of November) has substantially improved. Still, early sowing is the exception rather than the norm. Apart from awareness, there are other challenges [5,6] that restrict the farmers' ability to plant wheat on time, including, for example, the late establishment and harvesting of the preceding rice crop [7], the delayed clearing of rice plots due to poor farm mechanization, and the limited adoption of and/or access to zero-tillage wheat sowing equipment. Delay in wheat sowing after optimum time results in yield reduction by almost 1% per day [8].

The research was conducted at the landscape level for five consecutive wheat seasons starting from 2016–2017 to 2020–2021 on farmers' fields. The objective of this study was to quantify yield loss trends along the typical sowing date gradient and evaluate if the rate of decline was constant for the whole wheat sowing window. Another purpose of this work was to generate evidence on the comparative performance of long-duration wheat varieties (LDVs) and short-duration wheat varieties (SDVs) for different planting dates—do SDVs really outperform under late-sown conditions? Farmers are generally inclined towards SDVs in late-sown scenarios. The trial had five treatments of sowing time—(T1) 1 to 10 November, (T2) 11–20 November, (T3) 21 to 30 November, (T4) 1–15 December, and (T5) 16–31 December. T3, T4, and T5 had two sub-plots each of LDVs and SDVs. T1 and T2 had only LDVs because SDVs are generally planted after 20 November in field situations.

In the context of agronomic field research, the length and breadth of this dataset is quite large. The dataset can help agricultural researchers better understand the interannual variation of varietal yield response to planting date and the effect of seasonal weather conditions. Results of varietal performance can be re-validated by concerned institutions, as this has been a debated topic. Additional evidence for productivity gains from late-sown LDVs is needed before regional research and extension entities modify priorities to focus more on LDVs under late-sown conditions.

2. Data Description

The trial was conducted in two east Indian states—Bihar and Uttar Pradesh (UP). There were eight districts from Bihar and two from eastern UP, adjoining part of Bihar (Figure 1). Two types of wheat varieties were compared for yield performance based on time of sowing—LDVs and SDVs. Approximate maturing duration for LDVs and SDVs of wheat are 150 and 130 days, respectively.

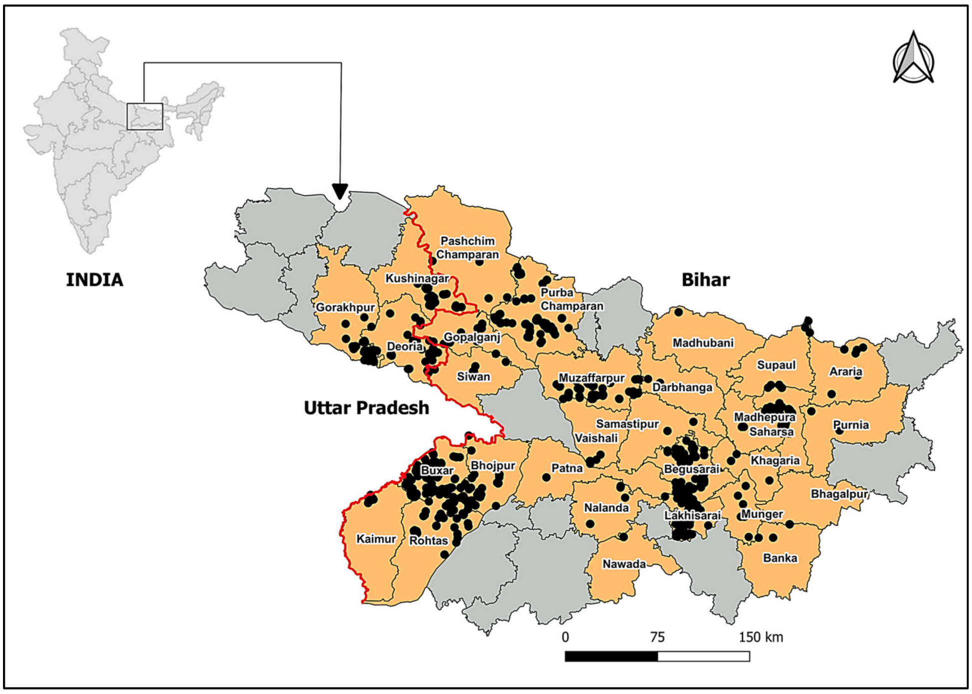

Figure 1. Map indicating locations of the trial. Black dots represent trial sites and red line denotes the boundary between Bihar and UP states.

2.1. Trial Location

This is the world's most densely populated area where rice and wheat (the two major cereals) are grown in rotation. The region is characterized by fertile soils due to alluvium deposition by the river Ganges. Annual precipitation is around 1500 mm, and ground water sources are also very rich.

2.2. Trial Coverage and Data Size

The trial consisted of five treatments based on the time of wheat sowing. T1, T2, T3, T4, and T5 denote wheat sowing from 1–10 November, 11–20 November, 21–30 November, 1–15 December, and 16–31 December, respectively. Varietal comparisons were done under T3, T4, and T5, as SDVs are mostly planted after 20 November. However, in some scenarios, they could be planted before, so they appeared in T2 at a few locations. The most commonly used wheat varieties by farmers were selected under both of the varietal classes. In the majority of cases, HD 2967 wheat variety was used for the LDV category, and PBW 373 was the predominant variety used in the SDV category. Out of 3735 sites, 2958 sites were located in eight districts of Bihar, whereas 777 sites were in two districts of UP (Table 1). Table 1 further segregates trial sites by treatment and variety class.

Table 1. Spread of trial in states and respective districts including the number of main and sub-plots over all of the five years.

State	District	Variety Class	T1	T2	T3	T4	T5	Grand Total
Bihar	Bhojpur	LDV	42	67	42	40	39	230
		SDV		10	33	34	26	103
	Begusarai	LDV	31	54	37	30	21	173
		SDV		2	26	26	21	75
	Buxar	LDV	47	65	71	50	51	284
		SDV		1	32	53	46	132
	East Champaran	LDV	53	103	79	78	67	380
		SDV		4	54	65	91	214
	Lakhisarai	LDV	29	50	35	41	36	191
		SDV		3	35	34	35	107
	Madhepura	LDV	56	85	104	91	79	415
		SDV		1	15	13	31	60
	Muzaffarpur	LDV	53	79	64	48	10	254
		SDV		1	24	12	10	47
	Rohtas	LDV	16	89	39	27	31	202
		SDV		1	30	31	29	91
	Total		327	615	720	673	623	2958
UP	Deoria	LDV	43	108	20	40	21	232
		SDV		16	27	86	41	170
	Kushinagar	LDV	41	110	41	58	18	268
		SDV		14	27	51	15	107
	Total		84	248	115	235	95	777
Grand Total			411	863	835	908	718	3735

2.3. Grain and Biomass Yields

Overall, the comparison of grain yields revealed that the yields of the LDVs were higher than the SDVs. The yield difference between them was around 1 ton ha^{-1}. The mean grain yield of LDVs in the top 10% cases was 5.95 ton ha^{-1}, whereas this value for the SDVs was 4.45 ton ha^{-1}. A similar comparison for the biomass yield of LDVs and SDVs highlighted a difference of slightly more than 2 ton ha^{-1} in favor of the LDVs. In the top 10% cases of LDVs and SDVs, the mean biomass yields were 14.16 and 10.81 ton ha^{-1}, respectively. These numbers very clearly indicate that LDVs have substantially higher potential (Figure 2).

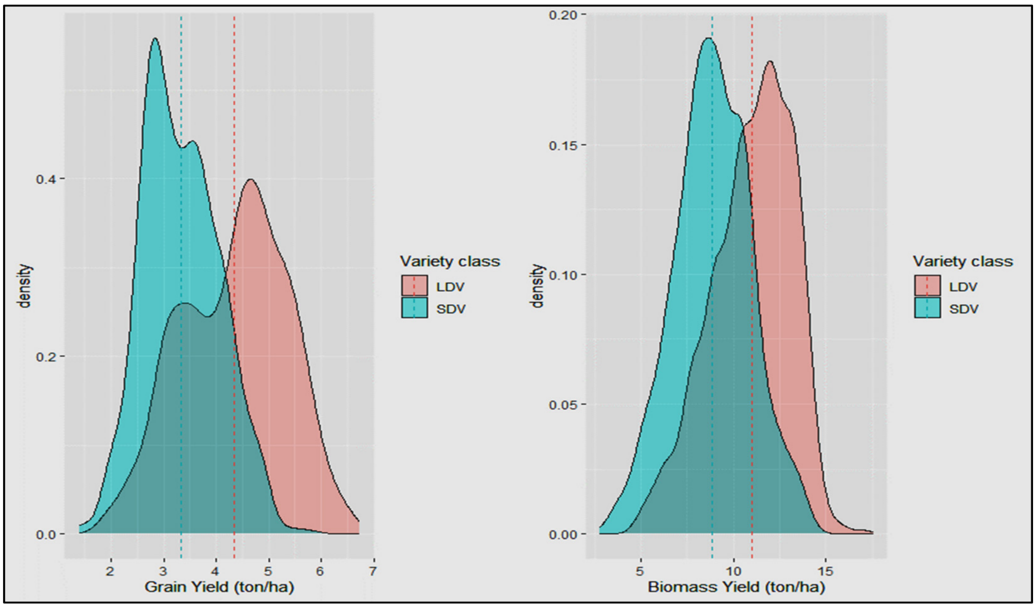

Figure 2. Paired histograms showing comparisons of the grain and biomass yields of LDVs and SDVs across all of the five years. Dotted vertical lines symbolize mean values of each respective varietal class.

2.4. Grain Yield Comparison among Treatments

There was a continuous decline in grain yield as the sowing time progressed, starting from 1 November for both varietal classes. In the first two treatments (T1 and T2), the mean grain yields of the LDVs were close to 5 ton ha^{-1}—slightly more in T1 than T2. Yield losses were expected for the SDVs (N = 53) in T2, so pairwise varietal comparisons were limited to T3, T4, and T5. Contrary to farmers' general perception of SDVs being suitable in late-sown scenarios, the LDVs outperformed the SDVs for all sowing date windows. In T3 and T4, the grain yields of the LDVs were approximately 0.5 ton ha^{-1} higher, whereas in T5 they were 0.4 ton ha^{-1} higher compared to the SDVs (Figure 3).

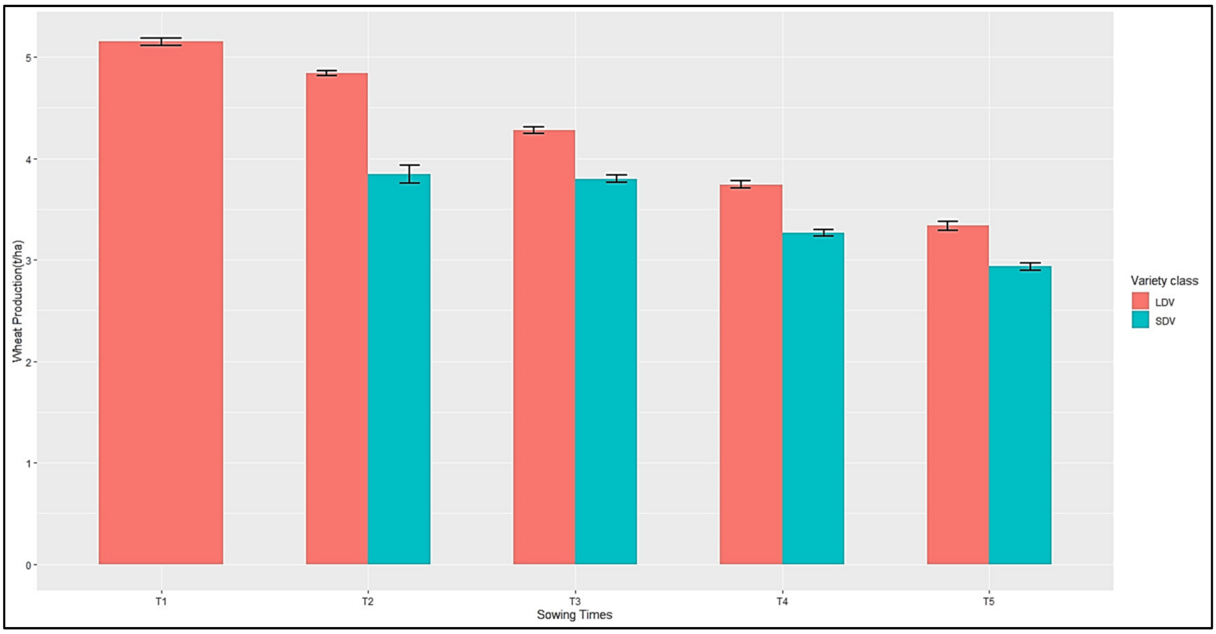

Figure 3. Comparisons of grain yields of the LDVs and SDVs in the treatments of the trial wherever applicable.

2.5. Comparison of Yields in Treatments for Each Year

Grain yield comparisons were individually investigated by year for all the years in which this trial was conducted in order to evaluate if aggregate trends deviate from annual trends among years. We observed similar results—grain yields of the LDVs decreased with later planting for all years, and the LDVs consistently outperformed the SDVs for all but one year (Figure 4). During 2020–2021 under T5, the yields of both varietal groups showed no significant difference (*t*-test *p*-value of 0.1467). The mean yields of the LDVs (N = 74) and SDVs (N = 74) for T5 were 2.8 and 2.9 ton ha^{-1}, respectively.

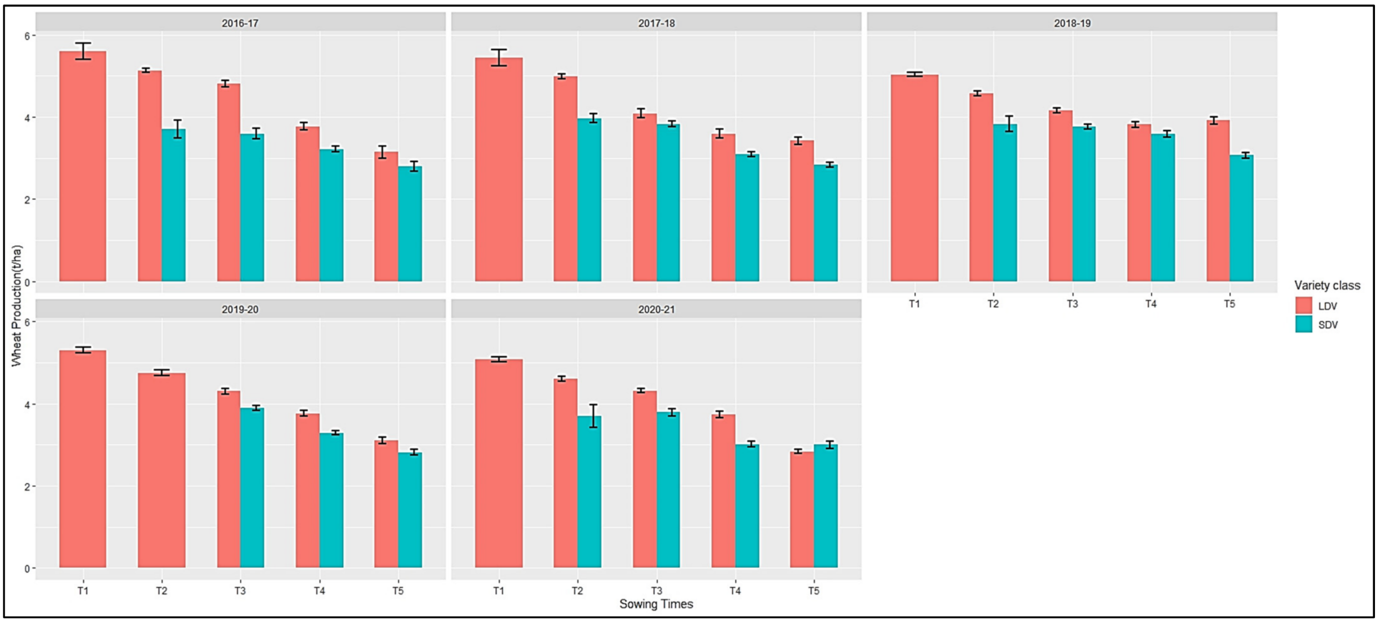

Figure 4. Yearly comparison of grain yields of the LDVs and SDVs in treatments of the trial wherever applicable. Error bars represent the 95% confidence interval of the mean.

Error bars in Figures 3 and 4 represent the 95% confidence interval of the mean. Due to the experiment's large sample size, error bars tended to be short in length, except for the SDVs in T2, which had a comparatively small sample size.

3. Methods

In the eastern Indo-Gangetic plain (IGP), wheat sowing is often delayed [9]. It can be characterized for the low yields of this area and reason for a high proportion of farmers using SDVs as compared to the western IGP. The eastern IGP was targeted for this study in order to address the dearth of reliable evidence based on actual field conditions regarding the performance of short- and long-duration varieties, and to generate new insights for informing policy decisions aimed at closing yield gaps in the region. Target districts were selected in such a way that the trials capture all four agro-climatic zones of this region [10] and reflect inconsistent wheat yields across these zones. Villages within a district were selected with the aim of maintaining sufficient spatial distance in order to represent typical district wise variation. For this study, sets of five treatments were applied at the village level on farmers' plots (Figure 5), with each roughly measuring 1 acre. Farmers' plots for treatments were different, as it was practically infeasible to plant wheat at five different times on single farmer's plot. Where possible, sub-plots (for LDVs and SDVs) were on the same field adhering to standard split-plot design [11]. Treatment details are as follows:

T1 (sowing during 1–10 November)—only LDVs
T2 (sowing during 11–20 November)—mostly LDVs
T3 (sowing during 21–30 November)—LDVs and SDVs in sub-plots
T4 (sowing during 1–15 December)—LDVs and SDVs in sub-plots

T5 (sowing during 1–10 December)—LDVs and SDVs in sub-plots

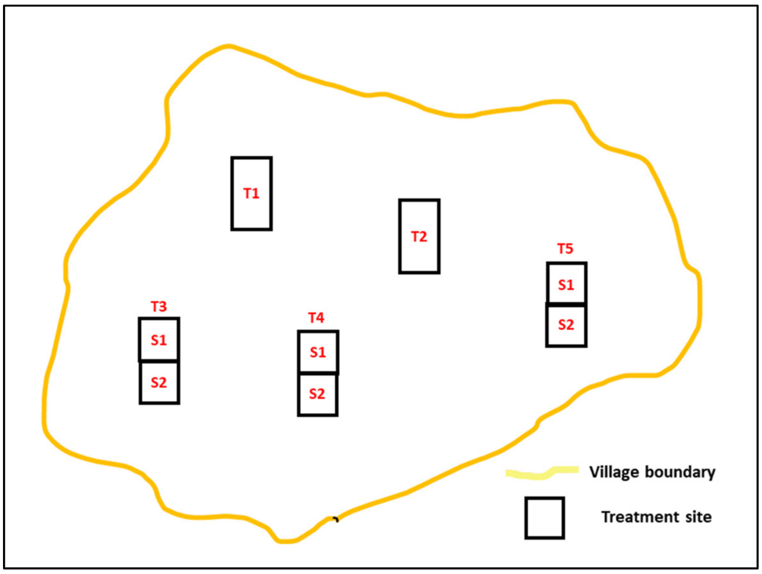

Figure 5. Illustration of the treatment distribution within a village.

In the data file, main-plot treatments are described by variable name 'SowingSchedule' (i.e., column 'S'). Sub-plot treatments are in column 'P' of our data file, as described by variable name 'VarietyClass'. Researchers can refer to these two variable columns (S and P) to run split-plot-related statistical analyses. Across five years of the experiment, the majority of the villages were selected repeatedly. However, within a particular year, there was largely a single set of main plots with limited replication within a village.

District-level project implementors (agriculture scientists) had set up the trials. All variables (except grain and biomass weights) were captured prior to crop harvest. Grain and biomass yields were recorded in kilograms from 2 m × 2 m areas at three spots in each treatments/sub-plots. Data were compiled for each district separately and then aggregated at the central level. Curation was done by the lead agronomist and an anonymized dataset was uploaded on organization's Dataverse portal (https://data.cimmyt.org/) on 2 January 2023 adhering to donor's open data policy.

Grain and biomass yield recorded from three spots and measured in kilograms were converted into tons per hectare by the following formula in MS Excel:

$$\text{Grain/Biomass Yield (ton/ha)} = \text{average}((\text{spot1} + \text{spot2} + \text{spot3})/3) \times 2.5$$

where average of Grain/Biomass weight recorded in kilograms from three spots can also be divided by 1000 to convert the weight in tons and then the value can be multiplied by 2500 to calibrate the per hectare value. Alternatively, the above formula is the same but simpler.

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