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Assessing the performance of wheat (*Triticum aestivum* L.) varieties to diverse sowing dates

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Abstract
The experimental study for the research entitled "Assessing the Performance of Wheat (*Triticum aestivum* L.) Varieties to Diverse Sowing Dates'' was carried out at Agronomy Farm, B. A. College of Agriculture, A.A.U., Anand, Gujarat, India during *rabi* 2021-22. The design was split plot with three replications. The treatment comprised of five sowing times: S_1: 20th November; S_2: 30th November; S_3: 10th December; S_4: 20th December and S_5: 30th December and the sub-plot consisted of three different wheat varieties: V_1: GW 451, V_2: GW 496 and V_3: GW 499. Soil of experimental plot was loamy sand in texture. For this experiment, a fertilizer dose of 120:60:00 NPK kg/ha was advised. The study aimed to investigate the effects of sowing time and varieties on the growth, yield attributes, yield and economics of wheat. The study assessed plant population, growth parameters: plant height (cm) and dry matter accumulation (g), yield attributes: total and effective tillers, spike length (cm), grains/spike, test weight (g), grain and straw yield (kg/ha), harvest index (%) and per day productivity (kg/ha/day). Sowing on 20th November resulted in higher plant height, total tillers, effective tillers, spike length, grains per spike and test weight compared to delayed sowing. It also led to higher grain and straw yield, harvest index and per day productivity. Among the varieties, GW 451 had the highest tillers, GW 496 had the longest spike and grains per spike, and GW 499 had the highest test weight. GW 451 also had the highest grain yield, followed by GW 499. Sowing on 20th November with GW 451 produced the highest returns and benefit-cost ratio. These results suggest that sowing on 20th November and selecting GW 451 can increase yield and net return in wheat cultivation, providing valuable insights for farmers and researchers.

Keywords: Wheat, varieties, sowing dates, GW 451, GW 496, GW 499

1. Introduction

Wheat is a vital cereal crop globally, serving as a staple food. Optimal yield is crucial for food security. It grows in temperate regions and higher altitudes during winter. Wheat is important for India's food security, with high protein content. Major wheat producers include China, India, the United States, Russia, and France. In 2021-22, global wheat cultivation covered 221.41 million hectares, producing 780.29 million tonnes (WAP, 2023) [1]. In India, wheat covered 31.13 million hectares, producing 109.59 million tonnes (WAP, 2023) [1]. Gujarat cultivated 12.54 lakhs hectares, producing 40.19 lakh tonnes in 2021-22 (DOA, 2023) [2]. Sowing time affects wheat growth and productivity. Untimely planting significantly impacts wheat crop yield (Singh *et al.*, 2021[a]) [3]. Normal sowing allows for longer growth, leading to higher biomass accumulation and greater grain and biological yields compared to late sowing (Singh and Pal, 2003) [4]. Sowing time is a critical factor affecting wheat yield potential, as observed by Hassan *et al.* (2014) [5]. Wheat sowing time varies with climate and variety (Madhu *et al.*, 2018) [6]. Late planting exposes wheat to high temperatures during the reproductive stage, resulting in reduced grain yield (Verma *et al.*, 2016) [7]. Late-sown wheat experiences both low temperatures during early growth and high temperatures during post-anthesis, negatively affecting grain development and yield (Jadhav, 2016) [8]. Timely sowing allows for optimum crop growth, higher biomass accumulation, and increased grain and biological yield (Habibi and Fazily, 2020) [9]. Advantages of sowing at the right time include improved seed germination, plant height, spikelet number, grain weight, and test weight (Keshry *et al.*, 2022) [10].

Varying sowing times impact crop performance. Understanding their effects on wheat growth and production is crucial for optimization. Furthermore, the choice of wheat variety plays a pivotal role in determining crop performance and adapting to specific agro-climatic conditions. Different varieties respond differently for their genotypic characters, input requirement, growth process and the prevailing environment during growing season (Sultana *et al.*, 2012) [11]. Identification of variety with specific date of sowing is essential for better yield of the crop (Madhu *et al.*, 2018) [6]. Evaluating the interaction between sowing time and wheat varieties can provide valuable insights into the adaptability and response of specific genotypes under different environmental conditions. By analyzing variety responses to different sowing dates, we sought to determine optimal sowing times for each variety, benefiting sustainable agricultural practices. The findings inform decisions of farmers on sowing time and variety selection, optimizing wheat production and improving sustainability. Additionally, the results contribute to knowledge on crop phenology, growth dynamics, and yield responses to changing conditions. Now a days farmers of Gujarat prefer late sowing of wheat in the field of kharif paddy, cotton or groundnut due to delayed harvesting. Some farmers are also believed that late sowing of wheat up to some period give good performance. Some newly developed varieties of wheat give good response even in late sown conditions. Keeping this in mind, the research topic is taken "Assessing the Performance of Wheat (*Triticum aestivum* L.) Varieties to Diverse Sowing Dates". This research paper will provide valuable insights into the interaction between sowing time and variety selection, contributing to the development of effective strategies for maximizing wheat productivity and meeting the increasing global demand for this vital cereal crop.

2. Materials and Methods

The field experiment was laid out in Plot A-6 at the Agronomy Farm, B. A. College of Agriculture, Anand Agricultural University, Anand, Gujarat, India. (22.58° N latitude and 72.92° E and 45.1 mm above the mean sea-level) during the winter (*rabi*) seasons of 2021-22. This centre is located in the Middle Gujarat Agro-Climatic Zone (AES-III) of Gujarat. The experimental field has an even topography with a gentle slope having good drainage. The soil samples were taken randomly from experimental plot to a depth of 0-15. The soil was loamy sand in texture, medium in organic carbon (0.53%), medium in available phosphorus (36.2 kg/ha) and available potash (208.69 kg/ha). Its pH was alkaline (8.19) and low in soluble salts. The experimental design followed a split plot design with five different sowing times as the main plot treatments and three wheat varieties as the sub-plot treatment with 3 replications. The treatments consisted of 5 sowing dates (S_1: 20th November; S_2: 30th November; S_3: 10th December; S_4: 20th December and S_5: 30th December) and 3 varieties. *viz*. V_1: GW 451; V_2: GW 496 and V_3: GW 499. Recommended dose of nitrogen, phosphorus and potassium (N: P_2O_5:K_2O @ 120:60:00 kg/ha) was applied through urea and DAP. Entire dose of phosphorus and half dose of nitrogen were applied to all the plots as basal dose in furrow prior to sowing and remaining half dose of nitrogen was applied at CRI stage *i.e.* first irrigation. Seeds were treated with Fipronil 5% @ 6 g/kg seed for termite control. The seeds of wheat varieties were sown by manually drilling in previously opened furrows at a distance of 22.5 cm between the rows @ 120 kg/ha. Fertilizers were placed below the seeds before sowing. After sowing seeds were covered with a thin layer of soil to avoid damage by birds in all the treatments. The first irrigation was given just after sowing and remaining irrigations were given as and when required by the crop. Pendimethalin @ 1 kg a.i. /ha was sprayed as pre-emergence for weed control 24 h after sowing. The left-over weed was controlled by one hand weeding at 30 DAS was carried out during the course of investigation. Neither serious disease nor pests were observed in the crop during the course of investigation, but in order to prevent infestation of termites drenching of Chlorpyrifos @ 25 ml of each plot was carried out. Harvesting of crop was done at physiological maturity stage. Plant stand at 15 DAS from each net plot five meter row length selected and counted. The average of effective per meter row was recorded. Growth and yield attributing characters. *viz*. plant height (cm) at 30, 60 DAS and at harvesting, dry matter accumulation at 45 DAS/m row length, total and effective tillers/m row length, spike length (cm), grains per spike, test weight (g) were recorded. Grain and straw yield, harvest index and per day productivity were recorded at harvesting of the crop. The net profit was worked out by deducting the total cost of cultivation from gross realization for each treatment and recorded accordingly. Benefit: costratio (BCR) is the ratio of gross realization to the total cost of cultivation was calculated by using the following formula.

$$\text{BCR} = \frac{\text{Gross return (₹/ha)}}{\text{Total cost of cultivation (₹/ha)}}$$

2.1 Statistical Analysis

The statistical analysis of the data generated during the course of investigation was carried out through software on computer following the procedure described by Cochran and Cox (1967) [12] by computer system at the computer centre, B. A. College of Agriculture, Anand. The variances of different sources of variation in ANOVA were tested by "F-test" and compared with the value of Table F at 5% level of significance. SEm ±, critical differences and co-efficient of variation (CV %) were also worked out.

3. Results and Discussion

Various factors related to crop production played a crucial role in increasing wheat production per unit area. Among these factors, the time of sowing and the selection of suitable varieties were particularly important in maximizing production. The objective of the experiment was to find out the effect of time of sowing and suitable varieties on growth, yield attributes and yield of wheat. To achieve the aforementioned objectives, the results and discussion of various parameters are presented below:

3.1 Effect of sowing times

3.1.1 Plant population

Plant population (per meter row length) of wheat at 15 DAS was found to be non-significant as influenced by different dates of sowing. It might be due to favourable weather condition during the germination period and also soil condition was good. It is reveals from the data that the plant stand of all the treatments was uniform and variations obtained in results were due to treatment effects and not due to the effect of plant stand.

3.1.2 Growth parameters

Plant height (cm) at 30, 60 DAS and at harvest was significantly higher when wheat sown on 20th November and it was at par with the 30th November and 10th December sowing. Additionally, the plant height at 60 DAS was also significantly at par with the sowing on 20th December. Whereas, significantly lower plant height at 30, 60 DAS and at harvest was observed in treatment S_5 (sowing on 30th December) (33.83 cm, 73.91 cm and 77.96 cm), respectively which was being at par with treatments S_4 and S_3 at 30 DAS and at harvest (Table 1).

The increase in mean plant height at 30, 60 DAS and at harvest was to the tune of 13.45, 12.54 and 13.19 percent in treatment S_1 (20th November sowing) over treatment S_5 (30th December). It is evident from the plant height data at 30, 60 DAS and at harvest that plant height reduced significantly when delayed sowing which is similar to the findings of Ram and Kaur (2020) [13], Yadav *et al.* (2017) [14] and Singh *et al.* (2022) [15]. Plant height may be decreasing due to a reduction in photoperiod available during active growth phases and a shortened maturity period for late sown treatments. These findings in line with those reported by Alam *et al.* (2013) [16], Dar *et al.* (2020) [17] who also observed that sowing times have significant effects on plant height and it decreased with late sowing.

Dry matter accumulation (g) at 45 DAS was significantly the highest in treatment S_5 (30th December sowing) compared to all other sowing dates. While significantly lower dry matter accumulation per meter row length at 45 DAS found in the treatment S_2 (30th November sowing), which was at par with treatment S_1 (20th November sowing). Dry matter accumulation at 45 DAS significantly increased from 20th November sowing to 30th December sowing (Table 1). It might be due to early sowing takes more days for crop growth as compared to late sowing and due to that in late sown wheat crop, early growth and spike initiation observed and due to this dry matter accumulation at 45 DAS found higher when wheat crop sown late.

3.1.3 Yield attributes

Sowing on 20th November (S_1) produced significantly higher total tillers and effective tillers (per meter row length) at harvest which were at par with 30th November (S_2) and 10th December (S_3) sowing. Treatment S_5 (30th December sowing) produced significantly lower number of total and effective tillers per meter row length, being at par with treatment S_4 (20th December) sowing. Based on the data presented in Table 2, percentage differences indicated that S_1 (20th November) had 0.67% higher effective tillers than S_2 (30th November), 2.95% higher than S_3 (10th December), 23.17% higher than S_4 (20th December) and 26.95% higher than S_5 (30th December). These findings suggested that selecting the optimal sowing date, such as S_1 (20th November), could enhance the number of effective and total tillers. It is evident from the data that number of effective tillers reduced significantly with delayed sowing dates which is similar to the findings of Yadav *et al.* (2017) [14]. It might be due to favourable environment available may have increase the nutrition to active growing part of plant which have the ability to multi shooting with favourable condition and that is why ultimately leads to higher shooting of the tillers to the base of the plant. Similarly, late wheat sowing produced poor yield attributes, which could be related to un-favourable weather in late sown conditions, which reduces cell division and cell expansion. Reduced cell expansion has a primary effect on the meristematic development of yield components such as inflorescences or tiller initiation in wheat, potentially resulting in small reproductive organs and lower yield. Higher number of effective tillers on early sowing dates may be the result of favorable temperature requirements that support crop growth through higher photosynthate accumulation and higher yield parameters in early-planted crops. These findings in line with those reported by Akhtar *et al.* (2002) [18], Yadav *et al.* (2017) [14] and Mehta and Dhaliwal (2020) [19].

Length of spike was recorded significantly superior under the sowing date 20th November and was at par with 30th November and 10th December sowing date. Treatment S_5 (30th December) sowing recorded significantly lower spike length (7.87 cm) which was at par with treatment S_4 (20th December). It is evident from data that the spike length reduced significantly with the delayed sowing which is similar to the findings of (Keshry *et al.*, 2022) [10] and Yadav *et al.* (2017) [14]. The reduction in spike length with delayed sowing might be due to altered phenology resulting in early heading. Under timely sown condition all weather parameters were favourable and due to that longer spike observed. These findings in line with those reported by Hossain *et al.* (2017) [20].

Grains per spike were recorded significantly superior under the sowing date 20th November and was at par with 30th November sowing. Delayed sowing produced lower grains per spike. Treatment S_5 (30th December sowing) recorded significantly lower grains per spike (35.0) which was also at par with treatment S_4, S_3 and S_2. Based on the data presented in Table 2, percentage differences indicated that treatment S_1 (20th November) had 11.00%, 17.21%, 24.80% and 26.26% higher grains per spike than treatments S_2 (30th November) S_3 (10th December), S_4 (20th December) and S_5 (30th December), respectively. These findings suggested that selecting the optimal sowing date, such as S_1 (20th November), could enhance the grains per spike. It is evident from data that the grains per spike reduced significantly with the delayed sowing which is similar to the findings of Yadav *et al.* (2017) [14]. The grains per spike were considered as the important yield contributing characters varied significantly under different date of sowing reported by Yadav *et al.* (2017) [14]. In 20th November sowing noticeably more grains per spike than all other sowing dates, which may be because the crop is subjected to a sudden rise in temperature and hot winds during the later stages of crop growth. During the milking stage, these unfavourable climatic conditions result in poor grain filling. Crops that were sown timely, however, had an advantage because, after successfully completing their vegetative growth, they entered their reproductive phase, during which the temperature rises steadily, favouring grain development and maturation Dar *et al.* (2020) [17].

Table 1: Plant population and growth parameters of wheat as influenced by different dates of sowing and varieties (2021-22)

Treatments			Plant population/meter row length (15 DAS)	Growth parameters			
				Plant height (cm)			Dry matter accumulation at 45 DAS (g)
				30 DAS	60 DAS	At harvest	
Main plot: Dates of sowing (S)							
S_1	:	20th November	26.98	38.38	83.18	88.24	78.11
S_2	:	30th November	26.40	37.52	81.98	86.00	74.24
S_3	:	10th December	25.07	35.67	80.22	83.47	85.26
S_4	:	20th December	26.07	35.11	77.16	80.56	98.47
S_5	:	30th December	25.44	33.83	73.91	77.96	110.13

S.Em.±	0.75	0.93	1.89	0.93	3.30
C.D. at 5%	NS	3.02	6.17	3.02	10.75
C.V. (%)	8.63	7.71	7.15	7.71	11.08
Sub plot: Varieties (V)					
V_1: GW 451	26.17	33.92	76.00	80.91	91.06
V_2: GW 496	25.67	37.84	82.07	85.93	86.59
V_3: GW 499	26.13	36.55	79.80	82.89	90.08
S.Em.±	0.44	0.50	1.07	1.27	2.46
C.D. at 5%	NS	1.47	3.17	3.75	NS
Interaction (S×V)					
S.Em.±	0.98	1.11	2.40	2.84	5.50
C.D. at 5%	NS	NS	NS	NS	NS
C.V. (%)	6.55	5.34	5.24	5.92	10.68

Sowing date 20th November (S_1) reported significantly the highest value for test weight (45.33 g). Looking to significantly lower test weight, it was observed from the data, test weight decreased with delayed sowing. Treatment S_5 (30th December) recorded significantly the lowest test weight (26.64 g). As per the data presented in Table 2, percentage differences indicated that 20th November sowing (S_1) had 9.40% higher test weight than 30th November (S_2), 25.27% higher than 10th December (S_3), 45.00% higher than 20th December (S_4) and 63.40% higher than 30th December (S_5). It is evident from data that test weight of wheat was reduced significantly with the delayed dates of sowing which is similar to the findings of Yadav *et al.* (2017) [14]. Comparison of grain size of wheat varieties influenced due to different sowing dates presented here in figure 1.The reduction in test weight with delayed sowing dates might be due to reduction in growth period and the shriveling of the grains as a result of the high temperatures during the milking and grain filling stages, the present findings are in close agreement with those reported by Yadav *et al.* (2017) [14]. Due to longer days to maturity and a longer time for photosynthates to be transported to developing grains, earlier sowing had the highest test weight, these findings in line with those reported by Ram and Kaur (2020) [13].

Fig 1: Comparison of grain size of wheat varieties influenced due to different sowing dates

3.1.4 Yield and harvest index

Sowing date 20th November (S_1) produced significantly higher grain yield (7760 kg/ha) and it was also statistically at par with sowing date 30th November (S_2) which produced (6946 kg/ha) grain yield. Sowing date 30th December (S_5) produced significantly lower grain yield (4433 kg/ha) which was at par with sowing on 20th December (5333 kg/ha).

Based on the data presented in Table 2, the grain yield production decreased with delayed sowing. The highest production noticed in 20th November sowing and the percentage was decrease to the tune of 42.87, 31.28, 21.48 and 10.49 over treatments S_5 (30th December), S_4 (20th December), S_3 (10th December) and S_2 (30th November), respectively. These findings suggested that selecting the optimal sowing date, such as treatment S_1 (20th November), could significantly enhance wheat yield, which held relevance for agricultural practices and crop management strategies. The highest yield was obtained with sowing on 20th November, which was a result of significantly higher plant height (Table 1), effective tillers (Table 2), spike length, grains per spike and test weight (Table 2). Significantly lower grain yield obtained with sowing on 30th December (4433 kg/ha), was a result of the lowest value of all these growth and yield attributes, which may have been caused by the shorter maturation period as compared to other sowing dates. The forced maturity of late sown wheat may be the cause of the decline in grain yield with delay in sowing, the present findings are in close agreement with those reported by Yadav *et al.* (2017) [14] and Singh *et al.* (2022) [15]. Wheat was sown in time to avoid heat stress and at the same time, the crop enjoyed more favourable weather conditions, which improved the growth and yield characteristics, leading to a higher yield, the findings are in conformity with those reported by Akhtar *et al.* (2012) [21], Patel *et al.* (2018) [22], Dar *et al.* (2020) [17], Mehta and Dhaliwal (2020) [19], Singh *et al.* (2021b) [23] and Singh *et al.* (2022) [15].

Treatment S_1 (20th November) recorded significantly higher straw yield (10496 kg/ha) and which was statistically at par with (S_2) 30th November (9543 kg/ha) sowing and (S_3) 10th December (9048 kg/ha) sowing. Treatment S_5 (30th December) sowing exhibits significantly lower straw yield (8534 kg/ha) and it was at par with all the treatments except S_1 (20th November). Treatment S_1 (20th November) sowing produced 22.99, 20.44, 16.00 and 9.99 percent higher straw yield than treatments S_5, S_4, S_3 and S_2. The most probable reason for higher straw yield in earlier sowing dates might be the presence of the optimal temperature and favourable environment which can cause the formation of taller plant and also increasing the rate of photosynthesis and increasing the transfer of photosynthates from various plant parts. Late sowing decreased the plant's growth phase, which in turn to decrease the straw yield. Delayed sowing reduced straw yield because the plant suffered from unfavourable phenological stages and produced fewer total and effective tillers, which in turn reduced straw yield. The results were supported by the findings of Mehta and Dhaliwal (2020) [19] and Singh *et al.* (2021c) [24].

It was observed that different sowing dates had significant effect on harvest index of wheat crop. First sowing date (20th November) reported significantly higher harvest index (42.49%) due to maximum grain yield obtained compare to other sowing dates and which was statistically at par with 30th November (42.13%) sowing and 10th December (40.21%) sowing. Whereas, treatment S_5 (30th December) sowing noticed in significantly lower harvest index (34.25%) followed by treatment S_4.

Different dates of sowing positively influenced to per day productivity of wheat crop. The data regarding per day productivity of wheat as influenced by different dates of sowing and varieties are presented in figure 2. Significantly higher per day productivity (73.15 kg/ha/day) was recorded in treatment S_1 (20th November) which was statistically at par with treatment S_2 (30th November) (67.40 kg/ha/day). Treatment S_5 (30th December) produced significantly lower grain yield per day which was also at par with treatment S_4 (20th December). Treatment S1 produced 54.06, 32.09, 20.02 and 8.53 percent higher per day productivity (kg/ha/day) than treatments S5, S4, S3 and S2, respectively. The decrease in per day productivity with delayed sowing dates was attributed to the reduction in grain yield.

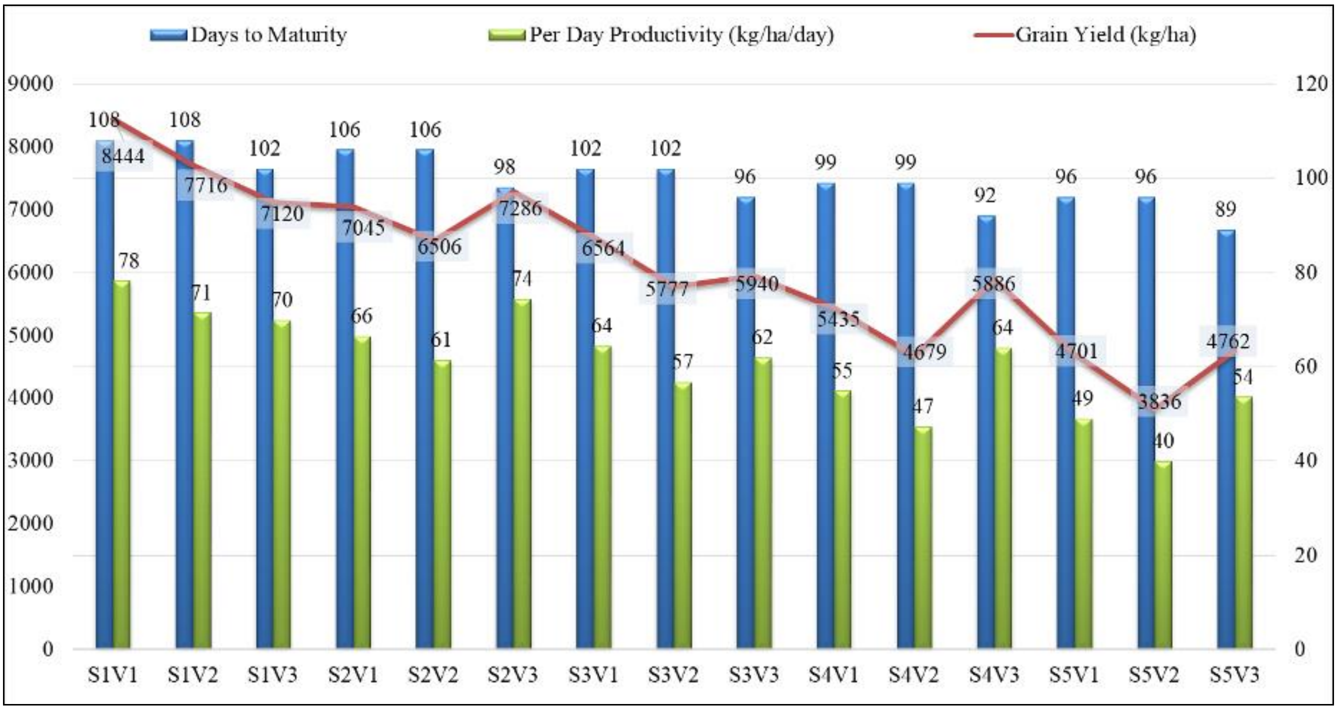

Fig 2: Days to maturity, grain yield and per day productivity of wheat as influenced by date of sowing and varieties

Table 2: Yield attributes, yield, harvest index and per day productivity of wheat as influenced by different dates of sowing and varieties (2021-22)

Treatments	Yield attributes					Yield (kg/ha)		Harvest index (%)
	Total tillers	Effective tillers	Spike length (cm)	Grains per spike	Test Weight (g)	Grain	Straw	
Main plot: Dates of sowing (S)								
S_1: 20th November	114.11	101.00	9.59	44.19	43.53	9.59	10496	42.49
S_2: 30th November	109.89	100.33	9.11	39.81	39.79	9.11	9543	42.13
S_3: 10th December	107.22	98.11	8.68	37.70	34.75	8.68	9048	40.21
S_4: 20th December	91.89	82.00	8.53	35.41	30.02	8.53	8715	37.88
S_5: 30th December	87.78	79.56	7.87	35.00	26.64	7.87	8534	34.25
S.Em.±	3.87	3.74	0.30	1.74	0.91	1.74	0.91	0.30
C.D. at 5%	12.61	12.19	0.98	5.67	2.96	5.67	2.96	0.98
C.V. (%)	11.36	12.16	10.26	13.59	7.78	13.59	7.78	10.26
Sub plot: Varieties (V)								
V_1: GW 451	109.67	100.13	8.37	36.69	31.18	8.37	9488	40.16
V_2: GW 496	95.67	85.67	9.56	42.27	29.87	9.56	9009	38.25
V_3: GW 499	8.34	36.31	43.79	36.31	43.79	8.34	9305	39.77
S.Em.±	2.29	2.55	0.20	0.92	0.64	0.92	0.64	0.20
C.D. at 5%	6.77	7.53	0.58	2.73	1.89	2.73	1.89	0.58
Interaction (S×V)								
S.Em.±	5.13	5.71	0.44	2.07	1.43	2.07	1.43	0.44
C.D. at 5%	NS	NS	NS	NS	NS	NS	NS	NS
C.V. (%)	8.69	10.72	8.66	9.32	7.11	9.32	7.11	8.66

3.2 Effect of Varieties

3.2.1 Plant population

Plant population (per meter row length) of wheat at 15 DAS was found to be non-significant as influenced by varieties.

3.2.2 Growth parameters

Significantly higher plant height (37.84 cm, 82.07 cm and 85.93 cm) was recorded in variety GW 496 (V_2) at 30, 60 DAS and at harvest, respectively which was also at par with variety GW 499 (V_3). Significantly the lowest plant height at all the stages observed in variety GW 451 (V_1). The variation in plant height of wheat varieties measured during different stage of wheat might be due to the genetic makeup of the individual varieties. These findings in line with those reported by El-khafagi *et al.* (2020) [25] and Patel *et al.* (2018) [22] who observed that varieties also significantly influenced plant height.

Fig 3: Plant height at 60 DAS influenced by different varieties

It was found that the different varieties had no significant effect on the dry matter accumulation at 45 DAS. It is also reflects in the data of straw yield at harvest (Table 1).

3.2.3 Yield attributes

Variety GW 451 (109.67 tillers) produced significantly the highest number of total tiller per meter row length at harvest. Variety GW 496 produced significantly lower number of total tillers (95.67 tillers) at harvest which was at par with variety GW 499.

Variety GW 451 (V_1) reported significantly the highest number of effective tillers (100.13 tillers) per meter row length. Whereas, significantly lower number of effective tillers per meter row length was measured in GW 496 (85.67 tillers) and GW 499 (90.80 tillers). Similar result observed by Pathania *et al.* (2018) [26]. Variety GW 451 produced 16.88% and 10.28% higher effective tillers per meter row length than varieties GW 496 and GW 499, respectively. GW 451 variety also produced higher number of total tillers, which is also possible reason behind higher number of effective tillers.

The data shows that, variety GW 496 (V_2) produced significantly the longest spike (9.56 cm). While, variety GW 499 (V_3) reported significantly lower spike length (8.34 cm) which was at par with variety GW 451 (V_1).

Treatment V_2 (GW 496) produced significantly the highest grains per spike (42.27). In case of significantly lower grains per spike in wheat, it was found in variety GW 499 and followed by variety GW 451.

There was a significant effect observed on test due to different varieties wheat. Variety GW 499 reported significantly the highest test weight (43.79 g). While, variety GW 496 produced significantly lower test weight which was also at par with variety GW 451 during the study.

The difference in all above yield attributes among the varieties could be attributed to genetic variability/makeup of different varieties. The present findings are in close agreement with those reported by Islam and Jahiruddin (2008) [27], El-khafagi *et al.* (2020) [25], Tripathy *et al.* (2020) [28], Patel *et al.* (2018) [22] and Hossain *et al.* (2017) [20].

3.2.4 Yield and harvest index

Different varieties has different yield potential and on the basis of that significantly higher grain yield was recorded in variety GW 451 (6438 kg/ha), which was statistically at par with variety GW 499 (6199 kg/ha). Whereas, variety GW 496 produced significantly lower grain yield (5703 kg/ha) and it was also statistically at par with variety GW 499. Variety 451 produced 12.89% and 3.86% higher yield than varieties GW 496 and GW 499, respectively. Difference between grain yield of wheat varieties might be due to difference in genetically and environmentally characteristics of the individual varieties. The highest grain yield was obtained from the GW 451 variety (6438 kg/ha), which resulted from significantly higher effective tillers, spike length, grains per spike and test weight Patel *et al.* (2018)

[22]. The lowest yield was obtained from the GW 496 variety (5703 kg/ha), which resulted from having the lowest value of effective tillers. Findings also from Singh *et al.* (2021[b]) [23] and (Keshry *et al.*, 2022) [10].

Different varieties failed to shows their significant effect on straw yield of wheat. It was also seen in dry matter production at 45 DAS (Table 2). It might be due to total and effective tillers were higher in variety GW 451 while plant height observed higher in variety GW 496, both this characters finally compensated in to equal straw yield.

Different varieties of wheat did not show their significant effect on harvest index.

Variety GW 499 produced significantly higher per day productivity (64.70 kg/ha/day) which was also statistically at par with GW 451 (62.57 kg/ha/day). Whereas, significantly lower per day productivity was found in variety GW 496 (55.34 kg/ha/day).

The higher per day productivity of variety GW 499 could be attributed to its early maturity characteristics (Table 2), while variety GW 496 took more days to maturity leads to lower per day productivity.

3.3 Interaction Effect

No significant interactions were observed between sowing times and varieties.

3.4 Economics

Treatment S_1 (20th November sowing) recorded maximum gross and net return of ₹ 1,83,952/ha and ₹ 1,32,056/ha, respectively with BCR 3.54. Second best treatment S_2 (30th November sowing) recorded gross and net return of ₹ 1,64,952/ha and ₹ 1,13,056/ha, respectively with BCR 3.54. Variety V_1 (GW 451) realized maximum gross and net income of ₹ 1,54,174/ha and ₹ 1,03,176/ha, respectively with BCR 3.02 followed by variety V_3 (GW 499) gross and net income of ₹ 1,48,789/ha and ₹ 97,791/ha, respectively with BCR 2.92. The treatment combination S_1V_1 (Variety GW 451 sown on 20th November) secured maximum gross as well as net return of ₹ 1,99,812/ha and ₹ 1,47,916/ha, respectively along with BCR of 3.85 (Table 3).

Table 3: Economics of different sowing dates and varieties of wheat

Treatments	Grain yield (kg/ha)	Straw yield (kg/ha)	Gross Return (₹/ha)	Fixed Cost (₹/ha)	Treat. cost (₹/ha)	Total Cost (₹/ha)	Net Return (₹/ha)	B:C Ratio
Main plot: Time of sowing (S)								
S_1: 20th Nov.	7760	10496	183952	39928	11968	51896	132056	3.54
S_2: 30th Nov.	6946	9543	164952	39928	11968	51896	113056	3.18
S_3: 10th Dec.	6093	9048	146049	39928	11968	51896	94153	2.81
S_4: 20th Dec.	5333	8715	129423	39928	10472	50400	79023	2.57
S_5: 30th Dec.	4433	8534	110161	39928	8976	48904	61257	2.25
Sub plot: Varieties								
V_1: GW 451	6438	9488	154174	39928	11070	50998	103176	3.02
V_2: GW 496	5703	9009	137781	39928	11070	50998	86783	2.70
V_3: GW 499	6199	9305	148789	39928	11070	50998	97791	2.92

4. Conclusions

In light of the results obtained from this investigation, following conclusions are emerged out. For getting higher yield and net return wheat crop should be sown at 20th and 30th November. Additionally, variety GW 451 produced significantly higher yield and net return followed by variety GW 499.

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6. Competing interests

The authors declare that there is no conflict of interest related to this article.

7. Author's Contributions

Mihir B. Modh: Conceptualization, Methodology, data collection, Analysis, Writing, editing.

Vinod B. Mor: Conceptualization, discussion, Review and editing, Supervision.

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