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Research Paper

Response of Various Sowing Date and Tillage Options on the Performance of Wheat under Late Sown Condition

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ABSTRACT

A field experiment was conducted at District Seed Farm (AB Block), Kalyani, under Bidhan Chandra Krishi Viswavidyalaya during the winter season of 2018 and 2019 in an upland situation *to assess the performance of wheat under different sowing dates along with tillage option in late sown condition.* The experiments were laid out in split plot design with four dates of sowing (25th November, 05 December, 15 December, and 25th December) confined in main plots and four tillage practices (viz. surface seeding, zero tillage, minimum tillage, and conventional tillage) in subplots and replicated thrice time. Wheat cv. 'DBW 107' All yield attributes were significantly influenced by the date of sowings. Early sowing revealed more effective tillers followed by higher grain per panicle and test weight. Various tillage practices, which were studied, showed significant variation for all yield-attributing traits. The effective tiller/m^2 was highest with minimum tillage and was at par with zero and conventional tillage practice and significantly superior to other measures. The final yield of a crop is the net result of growth and developmental activities in individual plants, which in turn would depend upon the genetic potential of the cultivars and the environmental condition to which it is exposed during the life cycle. The maximum and significantly more grain yield was obtained with 05th December sowing (34.15 q/ha) and showed parity with 25th November (33.89 q/ha) and 15th December (30 q/ha) sowing. This reduced grain yield drastically by the tune of 32.4, 31.6, and 22.7% less compared to the last date of sowing. Further straw yield was more found with the 25th November, and was at par with the 05 and 15th December sowing. With tillage measures, a significantly better grain yield (35.44 q/ha) was recorded with minimum tillage and was at par only with zero tillage (32.14 q/ha). Nutrient uptake patterns varied significantly concerning different wheat sowing measures. Sowing on 05th December registered more N, P, K uptake and was significantly better than all other main plot treatments, except for phosphorous, which showed parity only with the 25th November sowing. Further with various tillage measures, maximum nitrogen and phosphorus uptake was registered with minimum tillage than the other treatments and was at par only with zero tillage and significantly better than other treatments.

HIGHLIGHTS

- Late sowing up-to 5th December become effective for good yield of wheat in north eastern plain zone.
- Extreme delay sowing reduce yield to the tune of 35 to 40 percent.
- Suitable tillage options become effective under late sown condition.

Keywords: Growth, sowing, tillage, wheat, yield

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Food security dilemma is the problem of the future for countries like India where resources are getting stretched to the limits. Undoubtedly, intensive agriculture in irrigated areas has brought out substantial enhancement in foodgrain production but has also threatened environmental safety and promoted the degradation and inefficient use of basic resources and production inputs (Mukherjee, 2020). In the present situation, the only option is to shift towards environment-suitable technology and efficient utilization of production resources, especially soil, water, and nutrients. This becomes more imperative in the context of the wheat crop. Wheat is an important winter cereal in India. Globally, wheat is an important source of calories and energy for humans and accounts for a major share in the consumption basket. This has been cultivated around 270.8 million hectares with an output of 779.03 million tonnes ((ICAR-IIWBR, 2022).). In India, Rabi cereals are grown on 31.09 million hectares (23.78 % of total crop acreage), contributing 34.34 % of the total foodgrains produced during 2021-22 as per 4th Advance Estimate, Directorate of Economics and Statistics, Ministry of Agriculture and Farmers Welfare, India. In the current production season (2021-22) the wheat output is pegged at 106.84 million tones with a national average of 3484 kg/ha. In West Bengal, the wheat cultivated area is quite low, 220 thousand ha with a production of 660 thousand tons, with a productivity of only 2.9 t/ha (ICAR-IIWBR, 2022). In West Bengal productivity is quite low due to late sowing and poor agronomic management options. Further, West Bengal is not a traditional wheat-growing area in India. This crop has become a staple food crop next to rice, and its consumption is gradually increasing because of changes in food habits and economic prosperity. Despite a wide range of adaptability, little attention has been paid to wheat production and the maximization of yield potential of this crop in this state (West Bengal, Bihar, Jharkhand, etc.), and its share of national production is less than 1%. Productivity of 2.9 t/ha is also far below the national average of 3.5 t / ha (Source: DES, MoA&FW, India)). Amongst the various agronomic practices, appropriate time of sowing in a compatible manner with different resource conservation techniques become very effective for the crop yield and productivity and help maintain the food basket. After introducing high-yielding varieties, wheat became an important crop in West Bengal. Sowing of wheat in these areas gets delayed due to late harvesting of medium to long-duration rice, the previous crop in the rotation (Mukherjee, 2016). Wet soil conditions further enhance the delayed sowing of wheat, as it takes another 20-25 days to come in working condition. Delayed sowing resulted in a reduction of yield to the tune of 37.5 kg/ha/day (Jat *et al*. 2013). Delay sowing after mid-November decreases the yield potential of wheat by 1-1.5 percent per day (Hobbs and Gupta, 2003). Adopting resource conservation technologies (RCTs) as no-till is considered vital for improving wheat productivity. The prime drivers for zero and reduced tillage are not only water saving or natural resource management but also higher monetary gain (Ereinstein *et al*. 2008). There is an increased scientific interest in developing environmentally sustainable agricultural technologies that are resource-conserving while ensuring financial profit to the farmers. This paradigm shift is closely associated with increased awareness of the environmental externalities of conventional farming practices in the public and policy arena (Mukherjee and Mandal, 2021). In most crop production systems, soil tillage is one of the expensive items of expenditure and, thus, an economically important factor. It influences the physical, chemical, and biological processes and long-term productivity with effective control of weeds (Choudhary *et al*. 2017). However, tillage is not a growth factor for plants, and its effects are mainly indirect. Adoption of zero and reduced/minimum tillage for sowing of wheat with a zero-till drill or behind country plow advances the sowing time 10-15 days and also saves the time and cost involved in field preparation. Tillage practices strongly altered the physical properties of the topsoil and the productivity of crops (Kumar *et al*. 2014; Kahlon, 2014).

So, appropriate time of sowing with effective conservation agriculture practices suitably has become very important under the present context. The concept of tillage in wheat is recent in India and West Bengal in particular, and information regarding proper sowing time under the late sown condition with effective tillage measures is scanty. Keeping this aspect, the present investigation was carried out to assess the performance of wheat under various dates of sowing with different tillage options for higher productivity under late sown conditions.

MATERIALS AND METHODS

The field experiment was conducted at District Seed Farm (AB Block), Kalyani, under Bidhan Chandra Krishi Viswavidyalaya, during the winter season of 2018 and 2019 in the upland situation. The farm is situated at approximately 22° 56′ N latitude, and 88° 32′ E longitude with an average altitude of 9.75 m above mean sea level (MSL). The soil of the experimental field was loamy in texture and almost neutral in reaction having pH 7.2, organic carbon 0.42%, nitrogen 274.2 kg, phosphorus 20.3 kg and potassium 257.8 kg/ha. The experiments were laid out in split plot design with four dates of sowing (25th November, 05 December, 15 December and 25th December) confined in main plots and four tillage practices (viz. surface seeding, zero tillage, minimum tillage, and conventional tillage) in subplots and replicated the time thrice. Wheat cv. 'DBW 107' was sown 5 × 6 m plot size. The recommended fertilizer dose is 120:60:40 kg N, P_2O_5, and K_2O per hectare, respectively. The fertilizer doses were applied as per treatment. A basal application of half of N along with a full dose of P_2O_5 and K_2O were given as basal in the form of urea, single super phosphate (SSP), and muriate of potash (MOP), respectively. The rest of the nitrogen was top-dressed after the first irrigation. The crop was sown in lines 20 cm apart with a seed rate of 100 kg / ha after adjusting 1000 seed weight at 38 g. Three irrigations at active tillering, flag leaf emergence, and milking stages were given to the field. The crop was sown on a different date of sowing as per main plot treatments.

In surface seeding, seeds were correctly soaked, and planting of soaked seeds treated with fresh cow dung was made in the afternoon to save seeds from bird damage. Under zero tillage, stubbles were buried before sowing, and seed drill was used to allow the planting of wheat seeds into fields after rice harvest without plowing the field. In minimum tillage, two-disc harrowings was done at 10-15 cm depth in row zone only after the harvest of rice. Conventional tillage included two ploughing with a depth of 40-50cm followed by seedbed preparation with harrowing, and after this, sowing was done. Pre-emergence application of pendimethalin was given 2 days after sowing, followed by one hand weeding at 30 DAS for a complete check of weeds during the critical period of crop-weed competition. The crop was harvested on 03 April 2019 and 08 April 2020, respectively. Each plot was divided into almost equal halves before recording biometrical observations. Half of each plot was kept undisturbed to determine yield, and the remaining half was used for recording biometrical observations, including destructive sampling. Data on growth, yield components, and grain yield were recorded after the crop's harvest, whereas Leaf area index (LAI) was recorded at 60 days after sowing, as per the standard procedure. Crop samples were analyzed for uptake of nitrogen, phosphorus, and potash as per standard laboratory procedures (Jackson 1973). The experimental data were analyzed statistically by applying the technique of analysis of variance (ANOVA) prescribed for the design to test the significance of overall difference among treatments by the F test, and conclusions were drawn at 5 % probability level (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Growth parameters

Significant differences were exhibited with a different date of sowing and tillage practices on growth attributes (Table 1). With different main plot treatments, the highest plant height registered with the 5th December sowing and showed a par result with all other treatment measures except the extremely late sowing date. Tillage practices improved growth attributes (plant height and dry matter accumulation) significantly. Amongst all tillage practices, maximum plant height was registered with the conventional tillage options and was significantly better to all other main plot treatments except minimum tillage options. Aziz *et al.* (2016) reported that early sowing served as the most critical crop management option under changing climatic scenarios. In all cases, the appropriate sowing window would be helpful in avoiding higher temperatures during full vegetative growth and, ultimately grain filling stage at the end of the season. 25th November sowing registered more dry weight of the plant and was at par only with the 5th December and statistically better to all other treatments under various main plot

Table 1: Effect of tillage practices and fertility levels on growth parameter and yield attributer of wheat (Pooled data of two years)

Treatment	Plant height (cm)	Dry matter accumulation at harvest (g/m^2)	Leaf area index (60 DAS*)	Effective tiller/m^2 (No.)	Spike length (cm)	Grain/spike (No.)	Spike/m^2 (No.)	Grain weight/spike (g)	1000 grain weight (g)
Different sowing date									
25th Nov	98.73	411.78	3.58	234.34	7.51	43.83	253.23	2.07	42.05
05th Dec	100.44	399.36	3.57	246.66	7.52	46.47	235.33	1.98	40.73
15th Dec	98.55	319.25	3.48	241.50	7.28	36.01	241.31	1.53	41.30
30th Dec	95.36	310.44	3.01	218.31	7.14	31.38	205.26	1.67	39.41
SEm ±	1.21	3.51	0.06	4.85	0.31	1.16	4.58	0.21	0.94
CD (P=0.05)	3.41	11.43	0.18	13.31	NS	2.93	14.04	0.43	2.19
Tillage options									
Surface seeding	99.41	332.32	3.51	185.21	7.15	35.39	219.43	1.41	37.74
Zero tillage	96.43	374.07	3.32	247.54	7.23	40.13	224.31	2.06	39.28
Minimum tillage	97.21	387.24	3.50	261.73	7.36	42.64	263.64	2.17	45.55
Conventional tillage	100.03	349.21	3.41	245.64	7.61	39.26	227.73	1.63	40.63
SEm ±	1.53	4.61	0.07	6.33	0.28	0.84	6.49	0.15	0.87
CD (P=0.05)	4.16	13.42	NS	19.29	NS	2.13	18.73	0.45	2.26

* *Days after sowing; NS = Non significant.*

treatments. Dry matter accumulation was found more with the minimum tillage and showed parity with the zero tillage measures, and was significantly superior to best practices. Dry matter accumulation was 23.8 % more, with minimum tillage over the zero tillage practice at harvest. With various main plot sowing, more LAI was observed with the 25th November sowing and was at part with all the treatments except 30th December sowing. LAI failed to produce any statistical difference with a different subplot option. However, more were found with the surface seeding and was followed by minimum and conventional tillage measures. Results revealed that dry matter accumulation and LAI gave good responses with various dates of sowing and became quite distinct under the new alluvial zone of West Bengal.

Yield attributes

All yield attributes were significantly influenced by the date of sowings. The effective tillers, considered the most critical yield determinant trait, improved significantly with 5th December sowing. This gave a maximum number of effective tillers/m^2 than other dates of sowings and showed parity in all the main plot treatments except the extremely late condition sowings. Pooled data analysis revealed that 35.8% more effective tiller/m^2 was recorded with this treatment over the extreme late sowing condition. This might be due to increased cell division and cell expansion with the early sowing and ambient climate situation (Mukherjee, 2016). Various tillage practices which were studied, showed significant variation for all yield-attributing traits. The effective tiller/m^2 was highest with minimum tillage and was at par with zero and conventional tillage practice and significantly superior to other measures. Spike length failed to have any statistical difference neither in the main plot nor in subplot treatments. With various main plot treatments, spike length was more found with the 5th of December sowing and was closely followed by 25th November. However, with different subplot measures highest spike length was recorded with conventional tillage and was followed by minimum and zero tillage options. With various dates of sowings, 5th December sowing registered more grain/spike and was at par only with 5th November sowing and statistically better to other main plot treatments. Further observation revealed that the number of grain/spike observed more with minimum tillage and was significantly better than all other subplot treatments.

In the main plot more spike were observed with the early sowing, i.e., 25th November, and was notably better than other options except 15th December sowing. A number of spikes per meter square revealed that, amongst various subplot treatments, the highest registered with the minimum tillage options and was significantly better than all other treatments. Grain weight /spike was more observed with 25th November sowing and was closely followed by 05th December sowing and statistically better than all other main plot treatments. Further with various tillage options, more were found with the minimum tillage and showed parity only with zero tillage and notably better than other options. This corroborates the earlier finding of Nagrajan and Rane, 1997). Test weight produced significant responses with various treatments in the primary or subplot. Early sowing revealed more test weight and was followed by 05 and 15th December sowing. These were at par with each other and statistically better than other options. Further, the highest test weight was observed with the minimum tillage and was statistically better than all other treatments of subplots.

Yield parameters

The final yield of a crop is the net result of growth and developmental activities in individual plants, which in turn would depend upon the genetic potential of the cultivars and the environmental condition to which it is exposed during the course of the life cycle. Biomass production showed significant variation with a different dates of sowing and tillage practices (Table 2). The maximum and significantly more grain yield was obtained with 05th December sowing (34.15 q/ha) and showed parity with 25th November (33.89 q/ha) and 15th December (30 q/ha) sowing. The least grain yield was obtained with 25th December sowing; this reduced grain yield by the tune of 32.4, 31.6, and 22.7% less compared to the above sowing dates. Further data recording revealed that straw yield was more found on the 25th of November and was at par with the 05 and 15th of December sowing. The more grain yield and straw production were recorded with early sowing accrued mainly because of more dry matter accumulation and an increase in yield attributing traits. The analysis of grain yield showed differences among the different conservation practices under subplot treatments. Data revealed that a significantly better grain yield (35.44 q/ha) was recorded with minimum tillage and was at par only with zero tillage (32.14 q/ha). This was followed by conventional tillage practices (30.36 q/ha). This increase in yield could be accredited to higher numbers of effective tiller/m^2, grain/ear, grain weight/ear, and 1000 grain weight under a minimum tillage system. These findings

Table 2: Effect of tillage practices and fertility levels on yield parameter, nutrient uptake pattern and economics of wheat (Pooled data of two years)

Treatments	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)	Total uptake (kg/ha)		
				N	P	K
Date of sowing						
25 th November	33.89	58.25	36.78	129.54	20.62	142.36
05 th December	34.30	57.01	37.56	145.11	21.95	158.43
15 th December	30.00	54.24	35.61	119.05	18.94	124.19
25 th December	23.18	42.32	35.39	97.11	17.83	106.63
SEm ±	1.81	2.26	0.87	4.55	0.96	2.87
CD (P=0.05)	4.73	6.19	2.05	12.91	2.75	7.96
Tillage options						
Surface seeding	25.44	46.79	35.22	104.98	17.44	110.96
Zero tillage	32.14	60.75	34.6	133.11	20.84	143.95
Minimum tillage	35.44	58.43	37.75	138.65	21.57	163.89
Conventional tillage	30.36	45.87	39.83	114.06	18.46	113.08
SEm ±	1.48	2.41	0.77	3.36	0.78	2.76
CD (P=0.05)	4.12	7.24	2.26	10.01	2.16	8.03

are in confirmation with those of Mukherjee (2008). Delayed sowing of wheat under conventional tillage exposed to both the extremes of temperature (low temperature during early growth period, which restricts the vegetative phase, and high temperature during -the post-anthesis period, which reduces the duration of grain development) and, consequently, the grain yield compared other tillage options (Mukherjee, 2019).

However, the least grain yield was recorded with surface seeding practices, which might be due to poor seed germination. This treatment registered 28.3 and 20.8 % less grain yield over the minimum and zero tillage practices. Further observations showed that straw yield was maximum with zero tillage (60.75 q/ha) and was closely followed by minimum tillage, and both were at par with each other and significantly better than other measures. The modified microclimatic conditions within the field due to the lesser disturbance of soil in zero and minimum tillage resulted in reduced crop lodging and decreased insect-pest incidence owing to reduced canopy humidity which contributed towards enhanced crop straw yield (Fahong *et al.* 2004). Further, more harvest index with different date of sowings were found with the 05th of December and was at par only with the 25th November and statistically better than all other options. Under different tillage options, conventional tillage gave the highest harvest index and was at par with the minimum tillage.

Nutrient uptake pattern

Nutrient uptake patterns varied significantly with respect to different wheat sowing measures. Sowing on 05th December registered more N, P, K uptake and was significantly better than all other main plot treatments, except for phosphorous, where it showed parity only with the 25th November sowing. Further, with various tillage measures, maximum nitrogen and phosphorus uptake was registered with minimum tillage than the rest of the other treatments and was at par only with zero tillage and significantly better than other subplot treatments (Table 2). The uptake of potassium by wheat crop was highest with minimum tillage practice and was significantly better than all other tillage measures. Minimum tillage was found to be the best for nutrient mining as compared to other conservation practices. This perhaps was due to more dry matter production by crops and less nutrient (N, P, K) depletion by better management practices and subsequently more availability of nutrients to crops.

In consideration of the above observation, it can be concluded that in the alluvial zone of west Bengal, wheat could be sown within 05th December along with minimum tillage option to obtain higher grain yield and biomass production. These treatments gave higher growth and yield attributes along with higher yield indicating better resource utilization under good management practice.

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