Indian Journal of Agronomy **66** (4): 413–418 (December 2021)

Research Paper

Evaluation of bread wheat (*Triticum aestivum*) under semi-arid conditions of Punjab

MANDEEP SINGH[1], KANWALJIT SINGH[2] AND AVTAR SINGH BIMBRAW[3]

Faculty of Agricultural and Forestry, Guru Nanak Dev University, Amritsar, Punjab 143 002

Received: December 2020; Revised accepted: October 2021

ABSTRACT

A study was conducted during the winter (*rabi*) seasons of 2018–19 and 2019–20 at Amritsar, Punjab, to evaluate the influence of sowing time and split nitrogen on growth and yield of bread wheat (*Triticum aestivum* L.). The experiment was conducted in a split-plot design, consisting of 5 sowing dates (D_1, 25 October; D_2, 5 November, D_3, 15 November, D_4, 25 November and D_5, 5 December) in main plots and 4 split nitrogen treatments as N_1, 50 % at sowing + 25% at the first irrigation + 25% at the second irrigation; N_2, 25% at sowing + 50% at the first irrigation + 25% at the second irrigation; N_3, 50% at the first irrigation + 50% at the second irrigation; N_4, 50% at sowing + 50% at the first irrigation in subplots, replicated thrice. The results revealed that, plant height, dry-matter accumulation, leaf-area index and number of tillers decreased significantly with delay in sowing from D_1 to D_5 at all stages of plant growth. The grain and biological yields were significantly higher in D_1 sowing date than the other sowing dates, but remained at par with D_2. The pooled grain yield decreased by 4% from D_1 to D_2, 10% from D_1 to D_3, 16% from D_1 to D_4 and 23 % from D_1 to D_5 sowing dates. Significantly higher values of growth attributes and yield were recorded with split application of nitrogen N_4, which remained at par with N_1, and significantly better than other treatments. Time of nitrogen treatment N_4, resulted in more net returns (66,824 ₹/ha) and benefit: cost ratio (2.32) and was followed by D_1 sowing date for net returns (70,948₹/ha) and benefit: cost ratio (2.22).

Key words: Nitrogen, Sowing dates, Semi-arid, Wheat, Yield

Wheat (*Triticum aestivum* L.) is the most cultivated food crop worldwide owing to its wider adaptability to different agro-climatic and soil conditions. It is being consumed in various forms by more than one thousand million population of the world. Wheat grain contains more protein (12.6%) than other cereals and it has a relatively high content of niacin and thiamine. China leads world, in terms of area under wheat cultivation, followed by India, Russia and the USA in terms of production. In India, area under wheat cultivation was 29.1 million ha with productivity of 34.08 q/ha during the winter (*rabi*) 2018–19 (GoI, 2019). Punjab, known as the bread basket of India, has 3.52 million ha area with production of 18.26 million tonnes and average yield of 51.88 q/ha during 2018–19 (GoI, 2019). The crop is sensitive to variation in environmental conditions for better emergence, development and anthesis, is highly vulnerable to high temperature that affects the partitioning of biomass from vegetative to reproductive organs (Mukherjee, 2012). The decision of appropriate sowing date is a vital management practice to enhance the grain yield of wheat. Numerous studies have revealed yield advantage with early sowing and yield reduction under delayed sowing after the ideal time (Mukherjee, 2012; Ram *et al*., 2012; Meena *et al.,* 2015). The optimum time of sowing for wheat crop in India is first fortnight of November. Delay sowing after mid-November decreases the yield potential of wheat by 1–1.5%/day. The delay in sowing of crop is mainly because of late harvest of paddy crop, delay in field operations and climate changes etc. Under this situation, zero till seeding of the wheat provides an opportunity for achieving an earlier sowing of the wheat crop. Zero tillage primarily has a positive environmental impact savings of fossil fuel, reduced emissions of greenhouse gas, water savings (Erenstein and Laxmi, 2008).

In India, the demand for nutrient resources particularly NPK, is exceeding the supply and the competition for this scarce resource, is becoming intense in agriculture. Nitrogen is the key input amongst all primary nutrients, as it is directly involved in plant photosynthetic system. This is

Based on a part of Ph.D. Thesis of the first author, submitted to Guru Nanak Dev University, Amritsar, Punjab in 2020 (unpublished)

[1]**Corresponding author's email**: mandeepsingh283@yahoo.com
[1]Ph.D. Scholar, [2]Assistant Professor (Agronomy), Department of Agriculture, Khalsa College, Amritsar, Punjab 143 002; [3]Senior Agronomist (R), Department of Agronomy, Punjab Agricultural University, Ludhiana, Punjab 141 004

important for all recommended agronomic practices and therefore efficient utilization of nitrogen is essential for wheat. Imbalanced and improper time of use of nitrogen fertilizers warrants their judicious use to maximize fertilizer-use efficiency. Recovery of added nitrogen fertilizer is only 50% or less in most of the arable soils owing to volatilization, leaching and denitrification losses (Mukherjee, 2019). Hence appropriate time of nitrogen application in suitable proportion becomes very important under present context. So keeping all these factors in view, an experiment was conducted to assess the performance of wheat under different sowing dates with correct time and suitable proportion of nitrogen relevance under zero tilled conditions.

MATERIALS AND METHODS

A field experiment was conducted during the winter (*rabi*) season of 2018–19 and 2019–20 at the Research Farm area of Post Graduate Department of Agriculture, Khalsa College, Amritsar, Punjab. This site has hot moist and semi-arid type of climate with alluvial, medium available water-holding capacity soils. The mean values of minimum and maximum temperature recorded during the growing seasons of zero-till wheat ranged from 10.2 to 25.2 ^{o}C and 10.9 to 24.0 ^{o}C respectively. The value of minimum to maximum relative humidity during both the growing seasons of wheat was 38 to 94% and 39 to 91% respectively. The average sunshine hours during growing season of wheat ranged from 5.1 to 6.1 hr/day. The total amount of rainfall in growing seasons of wheat was 181 and 253 mm respectively. The soil of the field was sandy loam, having a *p*H 7.2, electrical conductivity 0.13 dS/m, low in organic carbon (0.31%), available nitrogen (248 kg/ha), medium in phosphorus (17.8 kg/ha) and available potassium (275 kg/ha). A total of 20 treatments were tested in a split-plot design with 3 replications by allocating date of sowing in the main plots and timings of nitrogen application to the subplots. The treatments comprised 5 sowing dates (D_1, 25 October; D_2, 5 November; D_3, 15 November; D_4, 25 November; and D_5, 5 December) with 4 methods of N application in split form as subplot, viz. N_1, 50% at sowing + 25% at the first irrigation + 25% at the second irrigation; N_2, 25% at sowing + 50% at the first irrigation + 25% at the second irrigation; N_3, 50% at the first irrigation + 50% at the second irrigation; N_4, 50% at sowing + 50% at the first irrigation. As per the treatments of sowing dates and nitrogen, crop was sown under zero-tillage condition in standing rice stubble after removing all the loose rice straw from the field. The wheat variety of 'Unnat PBW 343' was sown 2.5 m × 6 m in the experimental field using seed rate of 100 kg/ha by zero-tillage drill. The recommended dose of phosphorus at 62.5 kg/ha through diammonium phosphate (DAP) (18% N and 46% P_2O_5) and potassium at 50 kg/ha as MOP (60% K_2O) was applied through muriate of potash full basal dose before sowing and nitrogen of 125 kg/ha was applied in splits as per treatments. Basal dose of N was applied through DAP, whereas remaining N dose was top-dressed as urea (46% N) depending on the treatments. Irrigations and plant-protection measures were applied as per the crop need. The gramoxone (Paraquat) of 1,250 ml/ha was used for the control of weeds in experimental field before sowing the crop. Other crop-management practice were as per the local package of practices of the PAU (Package of practices for crops of Punjab, 2018–19). The harvesting of wheat was done manually on 15, 16, 18, 21 and 24 April, during 2018 for D_1, D_2, D_3, D_4 and D_5 treatments, respectively. During 2019, the crop was harvested, respectively on 18, 21, 22, 24 and 27 April. The data on growth and yield-attributing characters were recorded on 10 selected plants at the time of harvesting, whereas leaf-area index (LAI) was recorded 60 days after sowing as per normal procedure. The crop was threshed plot-wise and grain yield thus obtained from net plot was converted into kg/ha. The data obtained from 2 year study were analyzed statistically as per the procedure given by Gomez and Gomez (1984) using the CPCS1, software. The LSD values at P=0.05 were used to determine the significance between the different treatments. The effect of treatments was evaluated on pooled analysis basis on growth, yield attributes and yields.

RESULTS AND DISCUSSION

Growth characters

Plant height and dry-matter accumulation were significantly influenced by the date of sowing (Table 1). The maximum plant height and dry matter accumulation were recorded in the D_1 sowing date, which was statistically at par with D_2, and significantly superior to other dates of sowing in zero-tilled wheat. The percentage reduction in the plant height from D_1 to D_5 sowing dates was 17.6% at harvesting, and reduction for dry-matter accumulation was 39.3% at 120 days after sowing (DAS). Plant height decreased with deferral in sowing time due to of less favourable weather conditions and shorter crop-growing period. Meena *et al.*, (2015) reported reduction in plant height with delay in sowing time from optimum. Dry-matter accumulation was higher in early-sown crop because of favourable cool climate accessible for longer period as compared to late-sown crop (Kumar *et al.*, 2013). Leaf-area index was significantly influenced by date of sowing and split application of nitrogen at 120 DAS, and increased successively with advancement in age of the crop. The leaf-area index was significantly higher under D_1 sowing date than all other sowing dates. Meena *et al.* (2015) reported higher leaf-area index in the timely sown crop in view of cool climate accessible for longer period than that was accessible to late-sown crop.

Split application of nitrogen also influenced the plant height and dry-matter accumulation (DMA) significantly (Table 1). Split nitrogen N_4 showed the highest plant height and dry-matter accumulation, being at par with N_1, and significantly better than N_2 and N_3 treatments, respectively. The taller plant recorded with split application of nitrogen might be attributed to less leaching losses, better and timely utilization of available nitrogen during peak crop requirement and nitrogen promotes growth and development and enhances accumulation of protein, amino acids, which are responsible for hpertrophy and hyperlasia. This statement is in close conformity with the studies of Akarm *et al.* (2012). The increased DMA with split nitrogen application as 50% basal dose in N_4 and N_1 treatments might be happened due to the application of higher quantity of nitrogen during the initial stage resulting in fast and better growth, which enhances the plant height, LAI (Table1) and ultimately improved the DMA of zero-tilled wheat. Wagnan *et al.* (2002) also reported the similar results with split application of nitrogen. The highest leaf-area index noted under N_4 treatment was significantly superior to the other split applications of nitrogen.

Yield attributes

Sowing date had significant effect on number of effective tillers (Table 1). Postponement of sowing date significantly reduced the number of tillers, being significantly higher under D_1 than D_3 and D_4 treatments at all the growth stages. However, it was statistically at par with D_2 treatment. There was a progressive decrease in number of tillers, as the sowing date was delayed from 25 October to 5 December. The reduction in number of tillers with delay in sowing may be attributed to reduction in plant height, LAI and DMA (Table 1). Meena *et al.* (2015) also reported similar results. The ear length and number of grains/ear are two important yield-determining attributes. Both of these were significantly influenced by the sowing date. The ear length and number of grains/ear were significantly higher under D_1, but it was at par with D_2, and significantly better than other sowing dates. The percentage reduction in ear length and number of grains/ear from D_1 to D_5 was 23 and 15%, respectively. The reduction in number of ear length and number of grains/ear with delay in sowing may be attributed to reduction in LAI and DMA (Table 1). Similar results were obtained by Meena *et al.* (2015). The maximum value of the 1,000-grain weight was registered under D_1, while the minimum was under D_5 treatments.

Split application of nitrogen significantly influenced the effective tillers/m^2, ear length, grains/ear and 1000-grain weight in zero-tilled sown wheat (Table 1). The highest effective tillers/m^2 were observed under N_4, which was found to be statistically at par with N_1, and significantly better than N_2 and N_3 treatment. This could be owing to the fact that, nitrogen played a vital role in increasing sink size (Mukherjee, 2016). Nitrogen is required throughout the grand-growth period and hence adequate and regular supply might have a great role towards increased number of major yield attributes. Number of grains/ear and 1,000-grain weight were found higher under N_4 and were at par with N_1, and significantly better than all the other method of nitrogen use. Increased number of grains/ear might be attributed to positive role of nitrogen in cell expansion over

Table 1. Influence of sowing dates and split nitrogen on growth and yield attributes of zero-tilled wheat as affected by (pooled data of 2 years)

Treatment	Plant height (cm)	Dry-matter (t/ha)	Leaf-area index 120 DAS	Effective tillers/m^2	Ear length (cm)	Grains/ear (Nos.)	1,000–grain weight (g)
D_1	102.0	11.83	4.07	346	12.0	46.1	44.7
D_2	101.0	11.31	3.88	339	11.5	44.3	43.6
D_3	94.7	10.11	3.63	333	10.4	43.1	41.9
D_4	90.1	8.99	3.47	327	9.5	40.8	40.7
D_5	84.0	7.17	3.34	312	9.1	39.0	39.0
SEm±	1.0	0.16	0.05	3.2	0.24	0.55	0.44
CD (P=0.05)	3.0	0.53	0.15	9.8	0.8	1.8	1.45
N_1	100.5	11.76	3.88	354	11.1	45.4	43.9
N_2	92.6	10.02	3.58	333	10.4	41.3	41.7
N_3	88.3	8.84	3.29	319	9.2	39.0	40.0
N_4	101.1	12.11	4.02	359	11.7	46.6	44.7
SEm±	0.78	0.11	0.04	2.3	0.17	0.41	0.26
CD (P=0.05)	2.5	0.35	0.12	7.1	0.6	1.3	0.85

D_1, 25 October, D_2, 5 November; D_3, 15 November; D_4, 25 November; D_5, 5 December sowing; N_1, 50% N at sowing + 25% at first irrigation + 25% at second irrigation; N_2, 25% N at sowing + 50% N at first irrigation + 25% N at second irrigation; N_3, 50% N at first irrigation + 50% N at second irrigation; N_4, 50% N at sowing + 50% N at first irrigation

Days after sowing; NS, Non-significant

and above grain-filling (Naveed *et al.,* 2013).

Nutrient uptake

Nutrient uptake pattern of zero-tilled wheat significantly differed with dates of sowing (Table 2). The highest nitrogen in grain, straw and total uptake was observed under D_1 and notably better to the other treatments, at par with D_2 treatment. The maximum phosphorus uptake in grain, straw and total uptake for D_1 and D_2 treatment stood at par with each other and significantly better than the other dates of sowing. Potassium uptake by grain was the highest under D_1 treatment and significantly better than the other sowing dates, but the potassium uptake by straw and the total uptake was maximum under D_1 treatment, which was at par with D_2, and significantly superior to D_3, D_4 and D_5 treatment. The uptake of nutrients by crop is mainly a function of yield of that plant material and efficient development of root-system. With the delay in sowing time, the growth and yield of crop reduced, resulting low uptake of nutrients. Ferrise *et al.* (2010) also reported higher nitrogen uptake in grain and straw by wheat crop when sown at optimum sowing time than late sown wheat in France and higher potassium uptake by wheat in Varanasi, Uttar Pradesh. (Jat *et al.,* 2013).

Split application of nitrogen also influenced the nutrient uptake sown by zero-tilled wheat. The maximum nitrogen uptake found with N_4, was statistically at par with N_1, in grain, straw and total uptake, and significantly better than other treatments. Split nitrogen caused a corresponding increase in tissue contents of N in wheat plants (Ishaq *et al.*, 2001). The treatment N_4, took more phosphorus in straw and total uptake by wheat crop, and showed similarity with N_1 treatment, and considerably better than the other method of split nitrogen. Phosphorus uptake by grain in wheat found maximum with N_4 treatment, was statistically superior to the other method of nitrogen applications. Potassium uptake by grain in zero-tilled wheat crop was maximum under N_4 treatment, and significantly better than the other treatments. Straw and total potassium uptake was found to be the highest under N_4 treatment, which was at par with N_1, and significantly better than the other treatments. Higher dry-matter production with increased tissue N content perhaps attributed to this higher uptake. Kharub and Chander (2010) reported higher uptake of total nutrient with number of splits application of nitrogen.

Yield

Dates of sowing had significant effect on grain and straw yields of wheat (Table 3). The grain and straw yields were significantly higher under D_1 treatment, but statistically at par with D_2, and significantly better than all the other sowing dates. The grain yield decreased by 4% from D_1 to D_2, 10% from D_1 to D_3, 16% from D_1 to D_4 and 23% from D_1 to D_5 treatments. The decline in grain yield with delay in sowing could be due to shortening of the duration of each developmental phase and forced maturity of late-sown wheat, reduction in plant height , DMA, LAI, tiller density, ear length and number of grains/ear (Table 1). Our results confirm the findings of Gao *et al.* (2014). Higher straw yield under early sowings could be owing to higher

Table 2. Nutrient uptake of zero tilled wheat as affected by sowing dates and split nitrogen (pooled data of 2 years)

Treatment	Nitrogen uptake (kg/ha)			Phosphorus uptake (kg/ha)			Potassium uptake (kg/ha)		
	Grain	Straw	Total uptake	Grain	Straw	Total uptake	Grain	Straw	Total uptake
D_1	106.4	44.8	151.3	18.3	9.4	27.8	23.7	90.1	113.8
D_2	104.4	44.6	149.1	17.0	8.4	25.5	21.9	84.4	106.4
D_3	101.9	42.8	144.8	15.9	7.6	23.6	20.0	77.1	97.2
D_4	96.0	41.9	137.9	14.4	6.8	21.2	18.3	69.6	87.9
D_5	88.0	39.7	127.8	13.1	6.1	19.3	15.2	61.5	76.8
SEm±	1.4	0.28	2.0	0.32	0.36	0.71	0.4	2.1	3.4
CD (P=0.05)	4.4	0.93	6.0	1.1	1.3	2.3	1.2	6.5	10.7
N_1	102.1	46.3	148.9	15.0	9.6	24.6	17.9	80.0	98.0
N_2	96.2	42.9	139.1	13.8	8.3	22.1	15.4	75.1	90.6
N_3	86.9	37.6	124.5	12.6	7.7	20.3	12.6	69.0	81.6
N_4	107.8	47.5	154.3	16.7	10.0	26.7	19.8	84.7	104.5
SEm±	1.8	0.4	1.9	0.3	0.3	0.5	0.4	1.8	2.1
CD (P=0.05)	5.7	1.2	5.8	1.0	0.9	2.1	1.2	5.8	6.6

D_1, 25 October, D_2, 5 November; D_3, 15 November; D_4, 25 November; D_5, 5 December sowing; N_1, 50% N at sowing + 25% at first irrigation + 25% at second irrigation; N_2, 25% N at sowing + 50% N at first irrigation + 25% N at second irrigation; N_3, 50% N at first irrigation + 50% N at second irrigation; N_4, 50% N at sowing + 50% N at first irrigation

Days after sowing; NS, Non-significant

Table 3. Yield, harvest index and economics of zero-tilled wheat as affected by sowing dates and split nitrogen (pooled data of 2 years)

Treatment	Grain yield (t/ha)	Straw yield (t/ha)	Harvest index (%)	Gross returns (₹/ha)	Net returns (₹/ha)	Benefit : cost ratio
D_1	5.39	7.30	42.4	101,470	70,948	2.32
D_2	5.17	7.09	42.3	97,336	66,814	2.18
D_3	4.84	6.64	42.1	91,131	60,609	1.98
D_4	4.51	6.21	42.0	85,056	54,534	1.78
D_5	4.12	5.89	41.1	77,592	47,070	1.54
SEm±	0.06	0.1	0.8			0.05
CD (P=0.05)	0.22	0.30	NS			0.18
N_1	4.92	6.87	41.7	92,637	62,272	2.05
N_2	4.76	6.65	41.7	89,661	59,296	1.95
N_3	4.37	6.21	41.5	83,288	53,215	1.76
N_4	5.17	7.14	41.8	96,896	66,824	2.22
SEm±	0.05	0.08	0.6			0.04
CD (P=0.05)	0.19	0.24	NS			0.17

D_1, 25 October, D_2, 5 November; D_3, 15 November; D_4, 25 November; D_5, 5 December sowing; N_1, 50% N at sowing + 25% at first irrigation + 25% at second irrigation; N_2, 25% N at sowing + 50% N at first irrigation + 25% N at second irrigation; N_3, 50% N at first irrigation + 50% N at second irrigation; N_4, 50% N at sowing + 50% N at first irrigation
DAS, Days after sowing; NS, non-significant

growth and yield attributing characters, viz. plant height, LAI, DMA, number of tillers, grains/ear, ear length and 1,000-grain weight.

The grain and straw yields were significantly different due to split applications of nitrogen. The highest grain and straw yields were obtained from N_4, being significantly superior to N_2 and N_3 treatments, statistically at par in grain and straw yield of N_1, respectively. The lowest grain yield was recorded with N_3 treatment as compared to other split nitrogen treatments in the pooled data. The grain yield was decreased by 13.5 and 14.6% under N_3 treatment from N_4 treatment during 2018–19 and 2019–20 respectively. The results regarding enhanced grain yield ascertained by Samra and Dhillon (2002), reported that application of nitrogen in 2 splits, i.e. half and half at crown-root-initiation stage (CRI) stage, remarkably improved the grain yield over all other treatments. However, addition of 125 kg N/ha (50% basal + 25% at CRI + 25% at booting stage) gave the maximum grain yield, which was statistically similar with 100 kg N/ha in zero-tillage wheat as stated by Bartaula *et al.* (2020). This could be owing to various favourable factors under zero-tillage like proper placement of seed in narrow slit made by zero-till drill as well as emergence of wheat seedlings under favourble moisture content with right time of nitrogen application in split doses (Mukhrjee *et al.,* 2019). Pooled analysis clearly showed that, straw yield was the highest under N_4 treatment and was the statistically at par with N_1 treatment but significantly better than N_3 and N_2 treatment. Application of nitrogen in 2 and 3 splits to the early-sown zero-tilled wheat crop increased the straw yield owing to nitrogen throughout the growing period.

Economics

Of the different sowing dates, D_1 exhibited a higher gross returns (₹101,470/ha), net returns (₹70,948/ha) and benefit: cost ratio (B : C) ratio (2.32), being at par with D_2, and significantly better than other dates of sowing. It was mainly owing to less operational cost, as there was no cost incurred towards land preparation and other expenses as in conventional tillage. Maximum net return (₹54,262/ha) and benefit: cost ratio (1.73) were also recorded with 5 November sowing by Yusuf *et al.* (2019). Split application of nitrogen revealed that, N_4 treatment gave more net return (₹66,824/ha) and B : C ratio (2.22) being significantly better than N_2, N_3, but was at par with N_1, treatment.

Therefore, it can be concluded that wheat can be sown on 25 October to the first week of November (5 November) with split nitrogen of 50% at sowing + 50% at the first irrigation or with 3 splits of nitrogen as 50 % N at sowing + 25% at the first irrigation + 25% at the second irrigation to get the higher productivity and return from zero-tilled wheat.

REFERENCES

Akram, M., Ali, M., Mahmood, T., Munir, M.K., Saleem, M., Aslam, M. Asif, M. and Khakwani K. 2012. Impact of NPK application on the yield of wheat. *Crop and Environment* **3**: 58– 61.

Bartaula, S., Panthi U., Adhikari, A., Mahato, M., Joshi, D. and Aryal, K. 2020. Effect of different tillage practices and nitrogen level on wheat production under inner *tarai* of Nepal. *Journal of Agriculture and Natural Resources* **3**: 233–239.

Erenstein, O. and Laxmi, V. 2008. Zero tillage impacts in India's rice–wheat systems: A review. *Soil and Tillage Research* **100**: 1–14.

Ferrise, R., Triossi, A., Stratonovitch, P., Bindi, M. and Martre, P. 2010. Sowing date and nitrogen fertilization effects on dry matter and nitrogen dynamics for durum wheat. *Field Crops Research* **117**: 245–257.

Gao, Y., Yang, L., Shen, X., Li, X., Sun, J., Duan, A. and Wu, L. 2014. Winter wheat with subsurface drip irrigation (SDI): Crop coefficients, water-use estimates, and effects of SDI on grain yield and water use efficiency. *Agricultural Water Management* **146**: 1–10.

GoI. 2019. *Agricultural Statistics at a Glance*. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India, New Delhi.

Gomez, K.A. and Gomez, A.A. 1984. *Statistical Procedures for Agricultural Research,* Edn 2, pp. 693. John Wiley, New York.

Ishaq, M., Ibrahim, M. and Lal, R. 2001. Tillage effect on nutrient uptake in wheat and cotton as influenced by fertilizer rates. *Soil and Tillage Research* **62**: 41–53.

Jat, L.K., Singh, S.K., Latare, A.M., Singh, R.S. and Patel, C.B. 2013. Effect of dates of sowing and fertilizer on growth and yield of wheat (*Triticum aestivum*) in an Inceptisol of Varanasi. *Indian Journal of Agronomy* **58**: 611–614.

Kharub, A.S. and Chander, S. 2010. Effect of nitrogen scheduling on wheat *(Triticum aestivum)* productivity and quality under alternate tillage practices. *Indian Journal of Agricultural Sciences* **80**: 329–332.

Kumar, V.P., Rao, V.U.M., Bhavani, O., Dubey, A.P., Sidhu, P.K., Patel, S.R. and Venkateswarlu, B. 2013. Optimizing sowing dates and selection of varieties of wheat through long-term crop and weather analysis. *Journal of Agrometeorology* **15**: 67–72.

Meena, R.K., Parihar, S.S., Singh, M. and Khanna, M. 2015. Influence of date of sowing and irrigation regimes on crop growth and yield of wheat (*Triticum aestivum*) and its relationship with temperature in semi-arid region. *Indian Journal of Agronomy* **60**: 72–78.

Mukherjee, D. 2012. Effect of different sowing dates on growth and yield of wheat (*Triticum aestivum*) cultivars under mid-hill situation of West Bengal. *Indian Journal of Agronomy* **57**: 152–156.

Mukherjee, D. 2016. Influence of fertility levels on the performance of wheat cultivars under new alluvial zone of West Bengal. *Journal of Agroecology and Natural Resource Management* **3**(3): 206–208.

Mukhrejee, D. 2019. Enhancement of productive potential of wheat (*Triticum aestivum* L.) under different tillage and nitrogen management nitrogen startagies. *Indian Journal of Agronomy* **64**: 348–353.

Naveed, K., Khan, M.A., Baloch, M.S., Khan, N. and Nadim, M. 2013. Effect of time of nitrogen application on morphological and physiological attributes of dual-purpose wheat. *Pakistan Journal of Botany* **45**: 1,299–1,305.

Ram, A., Pannu, R.K. and Prasad, D. 2012. Effect of management practices on growth, yield and quality of late-sown wheat (*Triticum aestivum*). *Indian Journal of Agronomy* **57**: 92–95.

Samra, J.S. and Dhillon S.S 2002. Response of durum wheat (*Triticum durum* L.) to rate and time of nitrogen application under irrigated conditions. *Journal of Research* **39** (4): 269–272.

Wagnan, M.R., Oad, F.C. and Nenwani, K.S. 2002. Wheat growth and yield contributing characters under various sources and schedules of nitrogenous fertilizer. *Pakistan Journal of Applied Sciences* **2**:1013–1015.

Yusuf, M., Kumar, S., Dhaka, A.K., Singh, B. and Bhuker, A.2019. Effect of sowing dates and varieties on yield and quality performance of wheat (*Triticum aestivum* L.). *Agricultural Science Digest* **4**: 306–310.