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Effect of different sowing environments and nitrogen levels on growth and yield of wheat (*Triticum aestivum* L.) varieties

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Abstract
A field experiment was conducted during winter seasons of 2015-16 and 2016-17 on loamy sand soil at Jobner to study the effect of different sowing environments and nitrogen levels on growth and yield of wheat (*Triticum aestivum* L.) varieties. The experiment comprising twenty four treatment combinations involving two sowing dates (20 November and 10 December), three varieties (Raj-4083, Raj-3777 and Raj-4037) and four levels of nitrogen (control, 40, 80 and 120 kg ha^{-1}) were laid out in split plot design with three replications. Crop sown on 20 November recorded significantly higher growth and yield as compared to 10 December sown crop. A reduction of 16.4 per cent in grain yield and 19.7 per cent in straw yield were recorded in 10 December sown crop over 20 November. Among the wheat varieties, Raj-4037 was fond to be best and recorded significantly higher grain yield (4458 kg ha^{-1}) and straw yield (5675 kg ha^{-1}) than Raj-4083 and Raj-3777. Variety Raj-4037 recorded significantly higher plant height, total number of tiller m^{-1} row, dry matter accumulation/m row, LAI and chlorophyll content over Raj-4083 and Raj-3777. The growth parameters and available N, P, K content in soil after harvest were highest under 120 kg N ha^{-1} which was significantly superior over control and 40 kg N ha^{-1}. With increase in nitrogen level upto 120 kg ha^{-1}, there was significantly increase in grain and straw yield but remained statistically at par with 80 kg N ha^{-1}.

Keywords: Sowing dates, nitrogen levels, LAI, yield and wheat varieties

Introduction
Wheat (*Triticum aestivum* L.) is important cereal crop, grown under diverse agro climatic conditions in India. Wheat in India was grown on an area of 29.6 million ha with production of 99.7 million tonnes and productivity of 3371 kg ha^{-1} (GOI, 2018) [1]. Weather is one of the key factor influencing agricultural production and productivity. The physiological and physical processes of plants are temperature dependent. As evident, the increase in the rate of these processes corresponds to increase in yield. The optimum time of sowing can provide ideal conditions to have maximum light interception, best utilization of moisture and nutrients from early growth stage to grain filling stage. It governs the crop phenological development and total biomass production along with efficient conversion of biomass into economic yield. Because of genetic variation, different varieties of crop may differ in growth and development behaviour and response to different management practices (Singh *et al.*, 2010) [2]. Being a thermo-sensitive crop, choice of suitable variety for different sowing time further gets prime importance. Growing of suitable genotype at an appropriate time is essential for ensuring optimum productivity. Among essential plant nutrients, nitrogen plays key role in augmenting agricultural production and its deficiency limits crop production (Pathak *et al.*, 2003) [3]. Nitrogen is an essential constituent of plant proteins and chlorophyll and is present in many other compounds of greater physiological importance in plant metabolism *viz.*, nucleotides, Phospholipides, enzymes, hormones, vitamins etc. Nitrogen plays major role in early establishment of plant leaf area, increasing photosynthesis and root development to enable more efficient use of weather and water.

Materials and Methods
a field experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture, Jobner during winter seasons of two consecutive years, 2015-16 and 2016-17. Soil of the experimental site was loamy sand in texture and alkaline in reaction (8.3 and 8.2), low in available nitrogen (128.9 and 132.1 kg ha^{-1}), medium in phosphorus (15.3 and 14.9 kg ha^{-1}) and potassium (148.6 and 149.1 kg ha^{-1}) during the years 2015-16 and 2016-17, respectively.

The experiment was laid out in split plot design and replicated three times comprising twenty four treatment combinations keeping two sowing dates (20 November and 10 December), three varieties (Raj-4083, Raj-3777 and Raj-4037) in main plots and four levels of nitrogen (control, 40, 80 and 120 kg ha^{-1}) in sub plots. Wheat varieties were sown 5 cm deep in rows 22.5 cm apart. The seed rate used for sowing was 100 kg ha^{-1} for 20 November and 125 kg ha^{-1} for 10 December sowing. Nitrogen was applied through urea as per treatment. The recommended dose of phosphorus (30 kg ha^{-1}) was applied through single super phosphate at the time of sowing as basal. Half dose of nitrogen was drilled as basal at the time of sowing and remaining dose of N was top dressed in two splits. Other management practices were adopted as per recommendations of the crop under irrigated conditions. The periodic observations on growth parameters of the crop were recorded to evaluate the effect of treatments. Five plants were randomly selected in each plot and tagged permanently. Height of main shoot *i.e.* from the ground surface to base of fully expanded leaf was measured by metre scale and average plant height was worked out. For the purpose of recording dry matter accumulation per metre row length, the samples were dried in the air for few days and finally in oven at 65 ºC temperature till constant weight. The leaf area was measured with the help of portable leaf area meter at the experimental site. Chlorophyll content was determined as per the method advocated by Arnon (1949) [4]. At maturity, after leaving the two border rows on each side as well as 50 cm along the width of each side, a net plot area of 3.0 m x 1.35 m was harvested separately for recording the yield**.** The harvested material of each plot was tied up in bundles, tagged and kept on threshing floor for sun drying. The dried bundles of individual net plots were weighed separately to record biological yield, then threshed and winnowed manually. Soil samples were analyzed for available N, P and K content by adopting standard procedures. In order to test the significance of variation in experimental data obtained for various treatment effects, the data were statistically analyzed.

Result and discussion

Growth parameters

Significant differences were exhibited by dates of sowing on growth parameters (Table 1). Dates of sowing significantly influenced the growth parameters *viz.* plant height, total number of tillers m^{-1} row length, dry matter accumulation, leaf area index (LAI) and chlorophyll content. Crop sown on 20 November recorded significantly higher plant height (86.0 cm), total number of tillers/m row length (155.5), dry matter accumulation (249.0 g), LAI (4.59) and chlorophyll content (2.68 mg g^{-1}) with respective increase of 16.1, 27.8, 23.1, 19.8 and 15.5 per cent over 10 December sown crop. This was attributed due to maximum period available to 20 November sown crop in comparison to delayed sowing, resulting in taller plant. The probable reason for higher dry matter production and LAI in the early sowing was because of more favourable environment prevailing during the growth period. This was mainly because of production of more number of tillers $metre^{-1}$ row lengths at 20 November sowing (Shahzad *et al.*, 2007 and Pandey *et al.*, 2010) [5, 6].

Wheat varieties showed significant differences for plant height, total number of tillers, dry matter accumulation and leaf area index (Table 1). Plant height was significantly higher under variety Raj-3777 representing an increase of 9.6 per cent over Raj-4037 and remained at par with variety Raj-4083. Wheat variety Raj-4037 recorded highest dry matter accumulation and LAI which was significantly superior over Raj-4083 and Raj-3777. However, variety Raj-4037 produced significantly higher total number of tillers m^{-1} row length over Raj-3777 but remained at par with Raj-4083. The differences in plant height in varieties are due to their genetic constitution. The significant increase in biomass production under variety Raj-4037 could be ascribed to its higher tillering potential, which might have facilitated larger canopy development as reported by Jat and Singh (2004) [7] and Mattas *et al*. (2011) [8].

Table 1: Effect of sowing dates, varieties and nitrogen levels on growth parameters of wheat (pooled data of 2 years)

Treatment	Plant height (cm) at harvest	Total no. of tillers (m^{-1} row) at harvest	Dry matter accumulation (g) at harvest	Leaf area Index 90 DAS	Chlorophyll content (mg g^{-1}) at 90 DAS
Sowing dates					
20 November	86.0	155.5	249.0	4.59	2.68
10 December	74.1	121.7	202.3	3.83	2.32
S.Em +	0.9	1.7	2.3	0.05	0.03
CD (P = 0.05)	2.7	5.0	6.6	0.15	0.08
Varieties					
Raj-4083	81.3	147.1	222.7	4.16	2.51
Raj-3777	83.1	117.7	187.2	3.84	2.44
Raj-4037	75.8	151.0	267.0	4.63	2.55
S.Em +	1.1	2.1	2.8	0.06	0.03
CD (P = 0.05)	3.3	6.2	8.1	0.18	NS
Nitrogen levels (kg ha^{-1})					
0	74.5	119.0	178.3	3.73	2.30
40	78.0	136.2	223.5	4.12	2.46
80	82.9	147.6	247.0	4.44	2.60
120	85.0	151.6	253.7	4.56	2.65
S.Em +	1.0	1.8	2.5	0.05	0.04
CD (P = 0.05)	2.9	5.2	7.0	0.14	0.11

The data revealed that as the nitrogen application rate was progressively increased, the growth of wheat increased significantly. The significant increase in plant height, total number of tillers/m row length, dry matter accumulation, leaf area index and chlorophyll content was recorded by raising the nitrogen application from control to 80 kg N ha^{-1} but at par with 120 kg N ha^{-1} (Table 1). The increase represented with application of 120 kg N ha^{-1} was to the tune of 14.1, 27.4, 42.3, 22.3 and 15.2 per cent over control and 9.0, 11.3, 13.5, 10.7 and 7.7 per cent over 40 kg N ha^{-1} in plant height, total number of tillers m^{-1} row length, dry matter accumulation, leaf area index and chlorophyll content, respectively. The beneficial effects of 120 kg N ha^{-1} seems to be due to better nutritional environment in root zone required for growth and development of crop as well as in plant system (Khichar and Niwas, 2007 and Jat *et al.*, 2014) [9, 10].

Yield

The significant difference in grain and straw yield was recorded with different dates of sowing (Table 1). Higher grain and straw yield was obtained under 20 November sown crop which was significantly superior over 10 December sowing. Crop sown on 20 November recorded 16.4 and 19.7 per cent more grain and straw yield, respectively over 10 December sowing. Late sown crop (10 December) has exposed to higher mean temperature during reproductive phase as against the mean temperature under 20 November sown crop. This shortened the crop period and caused forced maturity resulted in shriveled grain ultimately low grain yield as well as straw yield under late sown crop as reported by Amrawat *et al.* (2014) [11].

Different varieties showed significant variation for grain and straw yield (Table 1). Variety, Raj-4037 was found to produced significantly more grain (4458 kg ha^{-1}) and straw yield (5675 kg ha^{-1}) over Raj-4083 and Raj-3777. Whereas, variety Raj-3777 produced lowest grain and straw than all other varieties. Variety Raj-4037 produced 15.7 and 25.1 per cent higher grain yield, 7.8 and 12.3 per cent straw yield over Raj-4083 and Raj-3777, respectively. High yield of Raj-4037 may be attributed to its higher biomass accumulation due to higher number of tillers and superior yield attributes. The results are in close conformity with Jat and Singh (2004) [7] and Dhaka *et al.* (2006) [12].

Table 2: Effect of sowing dates, varieties and nitrogen levels on yield and available nutrients status in soil after harvest of wheat (pooled data of 2 years)

Treatment	Yield (kg ha^{-1})		Available nutrients in soil (kg ha^{-1})		
	Grain	Straw	Nitrogen	Phosphorus	Potassium
Sowing dates					
20 November	4259	5808	141.73	23.73	126.10
10 December	3659	4854	150.08	25.47	133.89
S.Em +	32	62	1.59	0.29	1.49
CD (P = 0.05)	93	183	4.68	0.85	4.39
Varieties					
Raj-4083	3854	5264	144.98	26.07	131.05
Raj-3777	3565	5054	150.78	28.18	137.11
Raj-4037	4458	5675	141.94	19.56	121.83
S.Em +	39	76	1.95	0.35	1.83
CD (P = 0.05)	114	224	5.73	1.04	5.38
Nitrogen levels (kg ha^{-1})					
0	2859	4336	136.95	15.09	120.02
40	3912	5190	144.44	22.94	128.96
80	4485	5825	150.84	30.00	134.81
120	4580	5974	151.38	30.39	136.21
S.Em +	38	59	1.61	0.26	1.19
CD (P = 0.05)	106	166	4.52	0.74	3.36

Significant increase in grain and straw yield of wheat was recorded by raising the rate of nitrogen application (Table 1). Application of 120 kg N ha^{-1} to wheat fetched significantly higher grain and straw yield over control and 40 kg N ha^{-1} while it remained at par with 80 kg N ha^{-1}. The corresponding increase was 60.2 and 17.1 per cent in grain yield, 37.8 and 15.1 per cent in straw yield over control and 40 kg N ha^{-1}, respectively. As grain yield is primarily a function of cumulative effect of yield attributing characters, the higher values of these attributes could be assigned as the most probable reason for significantly higher grain yield. Straw yield was also recorded higher with increasing rates of N application. Improved biomass per plant at successive growth stages and increase in various morphological parameters like plant height, number of tillers etc. could be probable reason (Chaturvedi, 2006 and Yadav *et al.*, 2007) [13, 14].

Soil fertility

After harvest, analysis of soil revealed that different sowing dates had significant variation in available N, P and K content (Table 2). Crop sown on 10 December recorded significantly higher available N, P and K status of soil over 20 November sown crop. With the delay in sowing, the growth and yield of crop reduced, resulting low uptake of native nutrients by plant and leading to more quantity of nutrients as compared to normal sown crop. Data further revealed that the maximum available N, P and K content in soil was recorded under the variety Raj-3777 which was significantly higher over Raj-4037 and Raj-4083. The high yielding varieties required higher amount of fertilizers and higher nutrient removal by plants from soil.

After harvest of crop, available N was significantly affected by different treatments. Available N ranged from 136.95 to 151.38 kg ha^{-1} with minimum in control and maximum in 120 kg N ha^{-1}. Available P after harvest of wheat ranged from 15.09 to 30.39 kg ha^{-1} under different treatments. Application of 80 kg and 120 kg N ha^{-1} being at par in available P recorded significantly higher available P over control and 40 kg N ha^{-1}. Available K after harvest of wheat crop ranged from 120.02 to 136.21 kg ha^{-1} being lowest in control and highest in 120 kg N ha^{-1}. The treatment 120 kg N ha^{-1} recorded significantly highest available K over control and 40 kg N ha^{-1}. However, it remained at par with 80 kg N ha^{-1}. Similar results were observed by Lal Bahadur *et al.*, (2013) [15] and Singh *et al.*, (2013) [16] in wheat.

Conclusion

The study revealed that crop sown on 20 November with wheat variety Raj-4037 and application of 80 kg N ha^{-1} had maximum plant height, total number of tillers, dry matter accumulation, leaf area index, Chlorophyll content, grain and straw yield under semi-arid eastern plain zone of Rajasthan.

However there was no significant difference observed between 80 kg N ha^{-1} and 120 kg N ha^{-1}.

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