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Growth Analysis in Relation to Sowing Environments and Nitrogen Levels in Wheat Varieties under Irrigated Conditions of N-W Himalayas of Jammu and Kashmir

Vikas Gupta, Meenakshi Gupta[1], Sarabdeep Kour[2] and Rajeev Bharat[3]

Basmati Rice Research Centre (BRRC), SKUAST-J, Chakroi, R. S. Pura, Jammu -181 102, India
[1]Division of Agronomy, [2]Division of Soil Science and Agricultural Chemistry and [3]AICRP on Mustard, Division of PBG, SKUAST-J, Chatha-180 009, India
E-mail: vikasadr@gmail.com

***Abstract*:** Field experiments were conducted in *rabi* 2015-16 and 2016-17 at Agromet Research Farm, SKUAST-J, Chatha, J&K to evaluate the effect of sowing environments and nitrogen levels on growth parametres and yield of wheat (*Triticum aestivum* L.) varieties. Three wheat varieties (HD 2967, RSP 561 and WH 1105), 3 sowing environments (25th October, 14th November and 4th December) and 3 nitrogen levels (100, 125 and 150 kg/ha) were laid out in split split plot design. The results revealed that variety WH 1105 observed significantly superior growth parametres *viz.* dry matter accumulation, leaf area index, crop growth rate, specific leaf area and grain and straw yields as compared to HD 2967 and RSP 561. Variety RSP 561 recorded lowest parameters and yield. Among the sowing environments, the early sown (25th October) wheat crop envisages significantly higher values of growth parametres and grain yield. Whereas, statistically notable values of the same recorded in higher dose of nitrogen (150 kg/ha), but were at par with 125 kg N/ha. The low mean temperature during early growth period resulted in longer vegetative phase in late sown crop. However, higher values of mean minimum temperature during reproductive phase of normal and late sowing environment reduced the duration of reproductive phase as compared to early sown wheat crop.

***Keywords*:** Wheat, Varieties, Sowing environments, Dry matter, LAI, CGR, Yield, Temperature

Wheat (*Triticum aestvium* L.) is the second most important cereal crop in the world after rice and is one of the major sources of energy, protein and fibre in human diet (Arya et al 2012) and so it occupies an important position in agricultural sector and overall financial system especially in the Asian region. Its wide spread cultivation is due to its adaptation to different agro climatic conditions. Wheat, a major cereal crop of the world being grown in about all the countries of the world across the 6 Continents and is the staple food crop of India; cultivated in about 30.56 m ha with production of 99.70 MTs (ICAR-IASRI 2019). Selection of improved varieties and optimum sowing time play a remarkable role in exploiting the yield potential of the crop under particular agro climatic condition. The accumulated temperature is also considered as the principal factor which affects the year-to-year variation in development of various phenophases (Gupta et al 2020). Advance or delay in sowing date, increasing N application and choice of suitable variety with the best thermal requirement represent the main agronomic manipulations which help to maintain existing crop production levels (Ventralla et al 2012, Gupta et al 2021). The unfavourable environments created by high temperature mostly during reproductive stages especially grain filling stage could be minimized by adjusting the sowing time to an optimum time for different varieties, which are suitable for early, normal and late sown environmental conditions for assured higher yield (Gupta et al 2020a). Current estimates indicated that wheat crop grown on around 13.5 m ha in India is affected by heat stress (Sareen et al 2012). It is also reported by the various researchers that the cool period for wheat crop in India is shrinking, while the threat of terminal heat stress is expanding (Gupta et al 2021, Gupta et al 2022a). Nitrogen is a key element for plant nutrition and other management practices which ultimately increases the yield of wheat crop (Cui et al 2010). High yielding new varieties can never be fully exploited with the existing fertilizer practice and thus fails to provide adequate yield. Since the information about the response of wheat varieties to sowing environments and N-levels under low altitude irrigated sub-tropical region of Jammu under lower Shivalik zone of Himalayas is lacking. To overcome these circumstances, an experiment was planned by selecting a set of recommended wheat varieties under different sowing environments with enhanced N-levels.

MATERIAL AND METHODS

Study site: Field experiments were conducted during *rabi* 2015-16 and 2016-17 at Research Farm of Agromet

Research Centre, SKUAST-Jammu (Latitude $32^{0}39^{/}$ N, longitude $74^{0}58^{/}$ E and altitude 332 m amsl).

Experimental details: Three wheat varieties HD 2967, RSP 561 and WH 1105 were sown under three sowing environments 25th October (early), 14th November (normal) and 4th December (late) with three nitrogen levels (100, 125 and 150 kg/ha) and replicated thrice. The experiment was conducted in split split plot design. Half of the nitrogen along with full dose of phosphorus and potassium was applied at the time of sowing as basal dose. The remaining half of nitrogen was top dressed in two equal splits, *i.e.* at CRI and before booting stage of the crop. The recommended dose of P and K was 50:25 kg/ha for wheat crop. However, nitrogen was applied as per the treatment combinations. The meteorological data, *viz*. maximum and minimum temperature for the *rabi* 2015-16 and 2016-17 were recorded at Agrometeorlogical Observatory of SKUAST-Jammu which is situated at about 50 m from the experimental site.

Growth parameters: For calculating dry matter accumulation the biomass of the plants cut near to the ground at different growth stages, sun-dried and thereafter kept in the oven for drying (65±5^{0}C) till a constant weight obtained, thereafter dry matter calculated and expressed as g/m row length. From the biomass cut for dry matter accumulation, all the leaves were removed from these plants, counted and categorized into three groups of large, medium and small size. 2-3 representative leaves from each category were chosen and their area was measured with the help of leaf area meter (Leaf Area Software-Disha Info way). The leaf area was worked out by multiplying with the total number of leaves obtained category-wise and average leaf area/m^2 was worked out by further calculations. Leaf area index (LAI) was worked out.

$$\text{Leaf area index} = \frac{\text{Leaf area (m}^2\text{)}}{\text{Land area (m}^2\text{)}}$$

Specific leaf area was calculated as the ratio of leaf area (cm^2) to leaf dry mass (g) as per the formula (Yulin et al 2005):

$$\text{Specific leaf area (cm}^2\text{/g)} = \frac{\text{Leaf area (cm}^2\text{)}}{\text{Leaf dry mass (g)}}$$

The crop growth rate (g/m^2/day) for each observational stage was calculated by substituting the corresponding dry matter accumulation value of these stages in the formula (Radford 1967) to calculate the crop growth rate

$$\text{CGR (g/m}^2\text{/day)} = \frac{W_2 - W_1}{T_2 - T_1}$$

Where,

W_2=dry weight of crop plant at time interval T_2, W_1=dry weight of crop plant at time interval T_1

RESULTS AND DISCUSSION

Dry matter accumulation: Dry matter accumulation of wheat crop was significantly influenced by varieties, sowing environments and nitrogen levels at different intervals of time and continued to increase throughout the crop growing period up to the harvest (Table 1). At initial stages, the rate of dry matter accumulation was slow, which picked quickly with advancement in age of crop and again slowed down from 120 DAS onwards up to harvest signifying the typical pattern of sigmoid growth. Variety WH 1105 accumulated significantly higher dry matter followed by HD 2967. However, RSP 561 accumulated the lowest dry matter. Significant variation in dry matter accumulation in different wheat varieties might be due to their genetic variation (Prasad et al 2003, Jat and Singh 2004). Significantly superior higher dry matter accumulations were in wheat crop sown on 25th October followed by sowing environments 14th November and 4th December. Early sown crop got an advantage of favourable environmental conditions; might be higher fertilizer use efficiency which may have resulted in higher dry matter production in early sowing (Table 1). Delayed sowing reduced vegetative growth of the crop due to high temperature during the later stages which lead to lower dry matter production (Kaur et al 2010). The significantly higher dry matter accumulation observed by the crop when supplied by 150 kg N/ha which was statistically at par with 125 kg N/ha . However, dry matter obtained by 125 kg N/ha was significantly superior than at 100 kg/ha of N at all the stages. It might be due to increased cell division and cell expansion with the increased N availability (Kumar and Yadav 2005).

Specific leaf area: Specific leaf area (SLA) is an important index indicating the ratio of leaf area (cm^2) to leaf dry mass (g). Specific leaf area of wheat crop increased progressively with the advancement in crop age and a noticeable increase was observed between 60 and 90 DAS (Table 1). At various growth stages, specific leaf area recorded in WH 1105 variety were numerically higher than HD 2967 and RSP 561 varieties. As SLA is the leaf area per unit dry mass is an important trait in plant ecology as is associated with many critical aspects of plant growth and survival (Shipley and Vu 2002). Wheat crop sown on 25th October recorded higher specific leaf area followed by 14th November and 4th December sown crop (Table 1). Among the different N levels, numerically higher SLA recorded in 150 kg N/ha and was followed by the values recorded in 125 and 100 kg N/ha . The possible reason for the variation in SLA values might be ascribed to the fact that SLA values varied with the nutrients availability to the plants (Garnier et al 2001).

Crop growth rate: Crop growth rate (CGR) is an indicative of the pattern of rate of growth of crop plants during the growing period and it also determines the successive accumulation of dry matter at different periods of crop growth (Table 2). Wheat varieties at various growth stages showed non-significant differences with respect to CGR values except at 0-30 and 30-60 DAS. Crop growth rate of wheat varieties increased with the advancement in age of the crop and reached the peak values at 90-120 DAS; however, WH 1105 recorded numerically highest CGR at observations followed by HD

Table 1. Dry matter accumulation (g/m row length) and specific leaf area (cm^2/g) of wheat varieties as affected by various sowing environments and nitrogen levels

Treatments	Dry matter accumulation (g/m row length)					Specific leaf area (cm^2/g)				
	30 DAS	60 DAS	90 DAS	120 DAS	At Har	30 DAS	60 DAS	90 DAS	120 DAS	At Har
Varieties										
V_1: HD 2967	14.60	51.58	119.08	221.4	248.59	72.8	152.9	249.2	250.7	199.0
V_2: RSP 561	14.62	49.84	115.92	213.3	246.98	71.9	159.6	247.2	250.9	201.1
V_3; WH 1105	15.77	59.23	138.27	241.4	267.52	76.1	147.0	225.8	243.9	188.7
CD (p=0.05)	NS	7.03	17.09	16.87	13.88	NS	NS	NS	NS	NS
Sowing environments										
D_1: 25th October	16.97	61.32	143.14	246.90	282.64	88.4	161.3	226.7	238.2	178.2
D_2: 14th November	14.87	53.96	124.03	224.60	257.02	80.5	158.9	246.3	257.5	195.1
D_3: 04th December	13.15	45.37	106.10	204.60	223.43	51.9	139.2	249.1	249.9	215.3
CD (p=0.05)	1.2	6.87	9.38	8.97	8.65	NS	NS	NS	NS	NS
Nitrogen levels										
N_1: 100% RDN (100 kg N/ha)	14.00	49.96	118.02	214.70	240.37	72.8	152.1	240.4	246.5	197.6
N_2: 125% RDN (125 kg N/ha)	15.14	54.39	126.27	228.70	257.43	73.4	152.3	241.2	249.0	192.8
N_3: 150% RDN (150 kg N/ha)	15.84	56.31	128.97	232.60	265.28	74.6	155.1	240.6	250.0	198.3
CD (p=0.05)	0.97	3.85	7.06	7.84	6.37	NS	NS	NS	NS	NS

Table 2. Crop growth rate ($g/m^2/day$) and leaf area index of wheat varieties as affected by various sowing environments and nitrogen levels

Treatments	Crop growth rate ($g/m^2/day$)					Leaf area index				
	0-30 DAS	30-60 DAS	60-90 DAS	90-120 DAS	120 DAS At Har	30 DAS	60 DAS	90 DAS	120 DAS	At Har
Varieties										
V_1: HD 2967	2.14	5.42	9.90	15.00	3.98	0.35	2.04	4.12	3.40	2.37
V_2: RSP 561	2.14	5.17	8.69	14.30	4.95	0.33	1.97	4.03	3.33	2.33
V_3; WH 1105	2.32	6.37	11.59	15.10	3.84	0.38	2.23	4.33	3.66	2.58
CD (p=0.05)	0.17	0.65	NS	NS	NS	NS	0.17	0.18	0.20	0.17
Sowing environments										
D_1: 25th October	2.49	6.50	12.00	15.20	5.25	0.47	2.50	4.60	3.85	2.64
D_2: 14th November	2.18	5.73	10.28	14.80	4.75	0.38	2.18	4.23	3.58	2.47
D_3: 04th December	1.93	4.73	8.91	14.40	2.77	0.21	1.56	3.65	2.96	2.17
CD (p=0.05)	0.12	0.59	1.13	NS	1.68	0.04	0.12	0.16	0.17	0.11
Nitrogen levels										
N_1: 100% RDN (100 kg N/ha)	2.05	5.27	9.98	14.20	3.76	0.33	1.93	3.97	3.31	2.30
N_2: 125% RDN (125 kg N/ha)	2.22	5.76	10.54	15.00	4.22	0.36	2.12	4.21	3.51	2.46
N_3: 150% RDN (150 kg N/ha)	2.32	5.93	10.66	15.20	4.79	0.37	2.20	4.28	3.58	2.51
CD (p=0.05)	0.09	0.36	NS	NS	NS	NS	0.11	0.15	0.14	0.10

2967 and RSP 561. Alam et al (2013) also observed statistically similar crop growth rate among the different varieties. Statistically higher CGR values noticed in 25th October sown crop and followed by 14th November and 4th December sown wheat. Crop growth rate increased slowly at early stages of growth and reached the peak at about 90-120 DAS and thereafter, it declined. This was due to the maximum production of dry matter at early stages of plant growth at Jammu (Singh et al 2017). The periodic crop growth rate of wheat significantly influenced by different N levels at 0-30 and 30-60 DAS only and non-significant effects noticed during 60-90, 90-120 DAS and 120 DAS-at harvest. Significantly higher CGR was in 150 kg N/ha which were followed by statistically similar CGR at 125 kg N/ha and the lowest CGR in 100 kg N/ha. The fact behind these results might be that application of nitrogen resulted in increasing the proportion of protoplasm of cell wall material which caused an increase in the size of cell, which ultimately increased the growth parametres like dry matter accumulation (Alam 2013).

Leaf area index: Statistically higher leaf area index (LAI) values recorded in WH 1105 which was followed by HD 2967 and RSP 561 at all the growth stages (Table 2). However, the values of LAI at 30 DAS were unable to show any significant difference. The difference in LAI among the varieties may be referred to inherent difference between the varieties for LAI, number of leaves per plant and their tillering capacity during the growing seasons (Jatti 2013). Among the sowing environments, significantly lower LAI observed in 4th December sown crop and higher values were observed in 25th October sown wheat in all the periodic observations of LAI from 30 DAS to harvest. However, LAI decreased gradually after 90 DAS in all the sowing environments under study. The lower values of LAI in 4th December sown wheat might be due to curtailment of 20 days most active growth period on account of late sowing (Singh et al 2003). At the various growth stages, N levels affected leaf area index significantly. Statistically notable augmentation in leaf area index was in 150 kg N/ha at various time intervals. However, the wheat crop supplied with 125 kg N/ha recorded LAI values statistically similar to 150 kg/ha of nitrogen, which was followed by 100 kg N/ha at all the growth stages. Patra and Ray (2018) observed significant LAI values of wheat with an increase in N levels from 120 to 150 kg/ha.

Yield: Grain yield of wheat was significantly influenced by varieties, sowing environments and nitrogen levels in both the crop growing seasons and second year crop marked an improvement in grain yield over that of first year (Table 3). Among the varieties, WH 1105 recorded significantly superior grain yield as compared to the other two varieties. However, varieties HD 2967 and RSP 561 were statistically similar during both the years of experimentation. Similar trend was noticed for straw and biological yield of wheat crop. The higher grain, straw and biological yields of wheat could be attributed to greater genetic potential with efficient utilization of radiation by leading to production of maximum

Table 3. Performance of different wheat varieties as affected by various sowing environments and nitrogen levels

Treatments	Grain yield (kg/ha)		Straw yield (kg/ha)		Biological yield		Harvest index (%)	
	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17	2015-16	2016-17
Varieties								
V_1: HD 2967	4160	4395	5858	6378	10017	10773	41.5	40.8
V_2: RSP 561	3975	4255	5923	6488	9898	10743	40.2	39.6
V_3: WH 1105	4573	4617	6271	6748	10844	11365	42.1	40.5
CD (p=0.05)	332	184	329	281	501	338	NS	NS
Sowing environments								
D_1: 25th October	4707	4857	6614	7272	11321	12130	41.5	40.0
D_2: 14th November	4313	4649	5959	6696	10272	11346	42.0	41.0
D_3: 04th December	3687	3759	5479	5645	9166	9405	40.3	40.0
CD (p=0.05)	202	182	258	254	345	397	1.36	0.78
Nitrogen levels								
N_1: 100 % RDN (100 kg N/ha)	3955	4179	5652	6263	9607	10441	41.1	40.0
N_2: 125 % RDN (125 kg N/ha)	4313	4471	6103	6605	10416	11076	41.3	40.4
N_3: 150 % RDN (150 kg N/ha)	4440	4616	6297	6747	10737	11363	41.3	40.6
CD (p=0.05)	135	141	201	156	248	259	NS	NS

leaf area and dry matter which in turn results into higher yields. Similar results were also reported by Jatti (2013) and Gupta et al (2022). Variety WH 1105 performed significantly superior to HD 2967 at various locations as reported in the report of AICWBIP (Tiwari et al 2015-16). Grain yield of wheat crop was affected to a great extent due to different sowing environments. Delayed sowing adversely affected the yield of wheat crop. Significant higher grain yield was observed in early sown conditions (25th October) and followed by statistically lower values registered with normal and late sowings in both *rabi* 2015-16 and 2016-17. These two latter sowing environments also differed statistically significant from each other. Normal and late sown wheat recorded about 9.1 and 27.6% less grain yield than early sown crop. Similar trend was noticed for straw and biological yield of wheat crop. The possible reason behind the significant higher yield values in early sowing might be the availability of optimum environmental conditions for growth and development of crop which could have enhanced accumulation of photosynthates from source to sink and thus resulted in higher yield values (Ram et al 2012; Gupta et al 2021a). Wheat crop when applied 150% RN (150 kg/ha) performed outstanding with respect to grain yields in both years of experimentation but the values were at par with that of 125% RN (125 kg/ha). Recommended dose of nitrogen (100 kg/ha) also performed well but the values were significantly inferior to other two doses of nitrogen. Similar trend was noticed for straw and biological yields of wheat crop. Higher wheat yield in enhanced N levels (125 kg/ha) could be traced to adequately N fertilized crop benefitted from higher rates of N nutrition that might have resulted into more vigorous and extensive root system of crop leading to increased vegetative growth means for more sink formation and greater sink size, greater carbohydrate translocation from vegetative growth (Hameed et al 2003).

From the data, it can be inferred that among the wheat varieties, the values of harvest index were statistically non-significant. However, sowing environments had a significant effect on harvest index values of wheat crop. Wheat crop sown on 14th November recorded higher values of harvest index but were statistically similar to earlier sown wheat. Different N levels also had non-significant effect on harvest index of wheat crop. However, numerically higher values of harvest index observed in 150 kg N/ha which was followed by the values recorded in 125 and 100 kg N/ha in the years 2015-16 and 2016-17. Decline in HI in later sowings as compared to early sowing might be due to higher temperature during reproductive stages in normal and late sowings (Dhyani 2010). The interaction effect of different varieties of wheat with N levels was significant during both seasons of experimentation (Fig. 1a). All the three varieties responded well to the enhanced nitrogen levels. Significant increment in grain yield was observed with an increase in N level from 100 to 125 kg/ha only; but thereafter increase in grain yield due to enhanced level of nitrogen was not significant. However, higher pace of response to increased dose of nitrogen with respect to grain yield was in WH 1105 followed by RSP 561 and HD 2967. Kaur et al (2016) also observed that different genotype varies widely in their yield response under different N management. Various sowing environments also interacted with N levels significantly for grain yield of wheat (Fig. 1b). Early sowing of wheat crop responded significantly to enhanced dose of nitrogen up to 150 kg/ha. Whereas, in case of normal sowing, significant response to nitrogen level was noted up to 125 kg/ha after that the increase in grain yield of wheat crop was not significant. However, crop sown on 4th December, responded significantly only up to 100 kg N/ha, on further enhancement of nitrogen dose, the grain yield of wheat crop did not increased significantly under late sown conditions. Dagesh et al (2014) observed a significant difference for interaction effects of nitrogen and sowing environments in wheat crop yield.

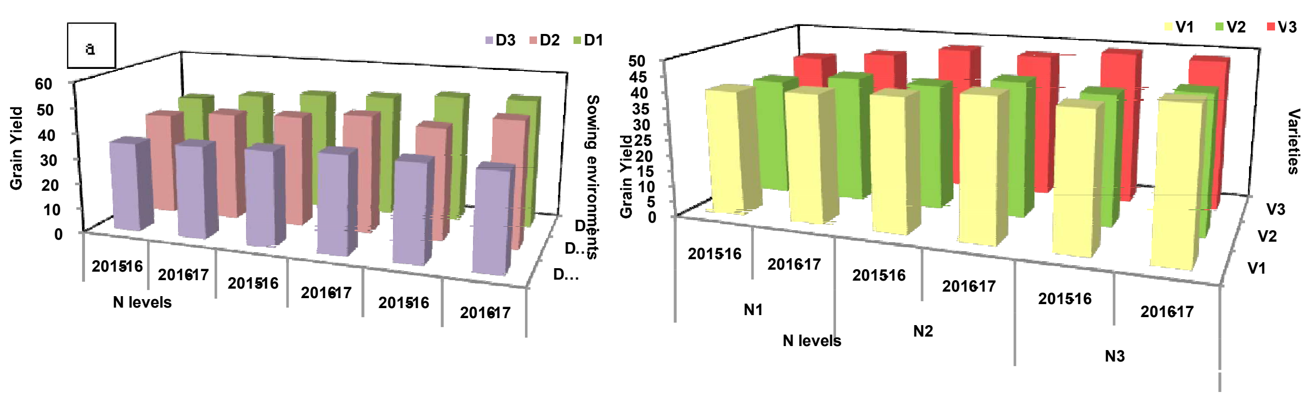

Fig. 1. Interaction effect of (a) N levels and sowing environments and (b) N levels and varieties on grain yield of wheat during *rabi* 2015-16 and 2016-17

Table 4. Effect of sowing environments on vegetative and reproductive period of wheat in relation to mean temperature

Sowing environments	Vegetative stage		Reproductive stage	
	Days taken	Mean T_{min}	Days taken	Mean T_{min}
D_1: 25th October	59	9.2	103	8.6
D_2: 14th November	65	6.5	85	10.1
D_3: 4th December	70	6.0	69	12.3

Weather studies; Days taken from sowing to attain various phenophases (vegetative phase) increased with delay in sowing. However, total crop duration decreased with delay in sowing, thereby decreasing the length of crop growing period (Table 4). The crop sown earlier (25th October) required more days (162) to attain physiological maturity as compared to normal (14th November) and late (4th December) sowings. The delay in sowing decreased the number of days required for maturity. The reproductive period of earlier sown wheat crop was longer (103 days) as compared to other two sowing environments *i.e.* 85 and 69 days under normal and late sowings, respectively. Thus, the reproductive period reduced significantly with delay in sowing by 18 and 34 days when the sowing was delayed by 20 and 40 days from earlier sowing environment (25th October), respectively. The low mean temperature during early growth period resulted in longer vegetative phase in late sown crop. However, higher values of mean minimum temperature during reproductive phase of normal and late sowing environment reduced the duration of reproductive phase as compared to early sown wheat crop. The similar findings were also reported by Gupta et al (2017). Khushu et al (2008) also reported that higher temperature during reproductive phase reduced the duration of late-sown *Brassica* crop.

CONCLUSION

Wheat variety WH 1105 recorded significantly higher growth parameters, yield and yield attributes over HD 2967 and RSP 561. Among sowing environments, 25th October sown wheat crop registered significantly higher values of all the yield attributing characters, grain and straw yield followed by normal and late sowing environments. The application of 150 kg N/ha recorded significantly higher yield attributes and yield of wheat crop as compared to the other N levels *viz* 125 and 100 kg/ha, but the values recorded in 125 kg N/ha remained at par with that of 150 kg N/ha. Among the interaction effects, higher wheat grain yield was obtained by sowing WH 1105 on 25th October and 14th November. Under late sown conditions, all the three varieties showed similar yield. However, variety RSP 561 performed similarly during early and normal sowing environments.

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