Indian Journal of Agricultural Sciences **80** (5): 380–4, May 2010

Evaluation of wheat (*Triticum aestivum*) genotypes for productivity and economics under graded levels of nitrogen in temperate Kashmir

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Received: 24 February 2009; Accepted: 10 January 2010

ABSTRACT

A study was conducted during winter seasons of 2005 and 2006 to find out the effective and economical rate of nitrogen for suitable genotypes of wheat (*Triticum aestivum* L. emend.Fiori and Paol.) under temperate conditions of Kashmir. The 4 wheat genotypes ('VL738', Shalimar 'wheat 1', 'HS 240' and 'HS 365') as influenced by 4 nitrogen levels (0, 50, 100 and 150 kg N/ha) were tested in a field experiment at Wadura. Genotype trend in grain yield ranged from 4.48 to 4.04 tonnes/ha in the order of 'Shalimar Wheat 1' > 'HS 365'>'HS 240'> 'VL 738'. 'Shalimar wheat 1' recorded highest grain yield which is 10.8%, 13.7% and 5.77% more over 'VL738', 'HS240' and 'HS365', respectively. Nitrogen-use efficiency indices at 100 kg nitrogen application (i e agronomy efficiency, 17.6 kg/kg, physiological efficiency, 57.41 kg/kg and N recovery =31.2%) also showed superiority of 'Shalimar wheat 1' over other genotypes. The optimum dose of nitrogen worked out from response equation of genotypes were 115.31, 122.35, 119.61 and 122.89 kg/ha, respectively. Among all the treatment combinations. 'Shalimar wheat 1' applied with 100 kg N/ha was found more economic with benefit : cost ratio of 2.25 under temperate valley conditions.

Key words: Nitrogen levels, NUE indices, Phenology, Relative economics, Wheat genotypes

Though climatic conditions of Kashmir valley are optimum for wheat cultivation, its production and productivity is low mainly due to lack of suitable genotype for temperate conditions. For identification of variety of greater suitability in existing climatic conditions, the study of growth and yield attributes would certainly has great significance to stabilize and sustain the productivity of wheat in the state. Nitrogen is an essential macronutrient and one of the main factors to be considered for realizing the potential of wheat cultivars. Nitrogen fertilization studies in temperate Kashmir have given conflicting results. This discrepancy regarding the fertilizer N requirement of wheat may be related to residual N in soil, differential cultivar response, varying climatic conditions etc. Concerns about the N-pollution of the environment such as nitrate leaching into the groundwater and nitrous oxide emission into the atmosphere, have stimulated interest in low input strategies for N fertilization (Ramesh *et al*. 2005). Based on the recent worldwide evaluation, the fertilizer N recovery efficiency has been found to be around 30% in wheat with current practices (Krupnik *et al*. 2004). The main reason of low nitrogen-use efficiency (NUE) is use of N in excess to the requirement. As genotypes vary widely, nutrients particularly nitrogen has got differential response. Hence, present investigation was undertaken to find out the optimum rate of nitrogen for different genotype under temperate conditions of Kashmir.

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MATERIALS AND METHODS

A field experiment was conducted during winter season of 2005 and 2006 at RRS and FOA, Wadura of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir. The experimental site was situated at 34.08° N latitude and 74.83° E longitude and at an altitude of 1587 m amsl. The soil was silty clay loam of Hapludalfs class with *p*H 6.86, EC 0.20 dS/M, N 333 kg/ha, P 6 kg/ha and K 199 kg/ha. The experiment was laid out in split-plot design consisting of 4 genotypes of wheat ('VL 738', 'Shalimar Wheat 1', 'HS 240' and 'HS 365') and 4 graded levels of nitrogen (0, 50, 100, 150 kg N/ha) with 3 replications. Wheat genotypes were sown on 20 and 22 November of 2005 and 2006, respectively using 100 kg seed/ha with 20 cm row spacing at a depth of 3 cm from the top of the soil by opening furrows through a liner. The full recommended dose of

phosphorus (26.18 kg P/ha), potassium (33.20 kg K/ha) and half of nitrogen as per treatment were applied at sowing as basal dose through di-ammonium-phosphate, muriate of potash and urea, respectively and rest of N is applied in 2 equal splits (crown root initiation and ear initiation stages). Dried straw samples were coarse ground using a Wiley Mill, and then both grain and straw were ground into a fine powder with a rolling ball and analyzed for total N by micro Kjeldahl method. Nitrogen uptake was calculated from the yield measurements and the total N content in the plant parts. The crop was harvested at physiological maturity on 5 and 7 June during 2005 and 2006, respectively. The nitrogen-use efficiency was computed as per expression given by Bock (1984), viz agronomic efficiency ($AE = Y_N - Y_0/F_N$), physiological efficiency ($PE = Y_N - Y_0/U_N - U_0$) and recovery efficiency ($RE = U_N - U_0/F_N$), where Y_N and Y_0 and U_N and U_0 were yields and nitrogen uptake in N fertilized and N_O (control) treatments, respectively and F_N is fertilized nutrient applied. The observations on crop growth, yield attributes and yield were recorded and relative economics was worked out considering the available market prices of inputs and produce. Harvest index and nitrogen harvest index were calculated as the ratios of seed dry weight to the total above ground dry weight and the seed N content to the total above ground N content at the maturity, respectively. Response curve of quadratic type of equation $Y = a + b\,N + cN^2$ of each genotype to nitrogen levels was fitted using least square technique as given in Snedecor and Cochran (1967). The physical doses ($-b/2c$) and optimum doses ($Q/P - b/2c$) were derived by differentiating the above functions with respect to N, where Q and P are the unit price of rice grain and nitrogen and b and c are the values of quadratic equation.

RESULTS AND DISCUSSION

Growth and yield attributes

The genotypes recorded marked variation in plant height, dry matter accumulation, number of tillers/m^2, ears/m^2, grains/ear and 1000-seed weight (Table 1). 'Shalimar wheat 1' and 'HS 365' were at par and superior in registering plant height, dry matter at harvest and ears/m^2, however with respect to number of grains/ear. 'Shalimar Wheat 1' was found significantly superior over the other genotypes. With the successive increase in N levels from 0 to 150 kg N/ha. Significant increase in growth and yield attributes was recorded. The magnitude of increase in these parameters decreased with successive increase in levels of nitrogen. However, there was not significant increase in growth and yield attributes by increasing nitrogen levels above 100 kg/ha except number of grains/ear which recorded a significant increase. The variation in growth and yield attributes of genotypes was mainly due to their specific response to nitrogen levels. These results confirm the findings of Nagarajan and Rane (2002).

Yields and harvest index

'Shalimar Wheat 1' recorded significantly higher grain yield, straw yield and harvest index over the other genotypes except 'HS 365' with respect to straw yield. (Table 1). Favourable effects of increasing levels of N on the growth and yield attributes of wheat got translated on the grain yield, straw yield and harvest index. 'Shalimar Wheat 1' recorded 10.9%, 13.7% and 5.7% increase in grain yield over the 'VL 738', 'HS 240' and 'HS 365' respectively and increase in straw yield was only 8.97%, 10.4% and 1.2% respectively. This explained high partitioning co-efficient of 'Shalimar Wheat 1' over the other genotypes in transporting photosynthates to the sink. This was further supported by significantly higher harvest index of 'Shalimar Wheat 1' and 'HS 365' over the other genotypes. Nagarjan and Rana (2002) also reported similar variation in grain yield, straw yield and harvest partitioning co-efficient among genotypes of wheat. If there would have been no sink limitation the performance

Table 1 Influence of genotypes and levels of nitrogen on growth and yield attributes, yields, harvest index, nitrogen uptake, N-use efficiency and relative economics of wheat (pooled data of 2 years)

Wheat genotype	Plant height at harvest (cm)	Dry matter at harvest (tonnes/ha)	Tillers/m^2	Ears/m^2	Grains/ear	1 000-grain weight (g)	Grain yield (tonnes/ha)	Straw yield (tonnes/ha)	Harvest index (%)	N uptake(kg/ha)		N-harvest Index
										Grain	straw	
'VL 738'	93.58	10.83	377.54	233.56	28.74	49.52	4.04	7.80	35.52	67.3	32.71	67.3
'Shalimar Wheat 1'	100.85	13.31	409.22	279.83	33.25	47.84	4.48	8.50	37.07	74.2	29.56	71.5
'HS 240'	98.74	12.88	363.27	251.62	29.55	55.94	3.94	7.70	35.22	64.4	29.50	68.6
'HS 365'	100.14	13.37	395.10	265.80	31.99	52.84	4.24	8.40	35.32	69	32.13	68.2
CD ($P = 0.05$)	2.38	0.341	7.74	5.17	1.14	2.03	0.135	0.327	0.35	2.1	1.5	
Levels of nitrogen (kg/ha)												
N_0	86.32	10.40	329.91	206.30	29.09	51.70	2.93	6.62	36.82	28.76	28.76	62.0
N_{50}	96.41	12.64	374.42	258.80	31.39	47.23	4.35	7.99	34.95	3015	3015	69.6
N_{100}	103.99	13.56	418.69	280.90	31.78	53.46	4.67	8.87	35.54	31.80	31.80	70.9
N_{150}	105.59	13.768	422.50	283.90	31.37	53.75	4.74	9.08	35.83	32.20	32.20	71.1
CD ($P = 0.05$)	1.85	0.225	5.01	6.2	0.71	1.06	0.215	0.201	0.184	2.1	2.1	

Table 2 Mean values of time required to each anthesis, maturity and grain-filling period of wheat cultivars as influenced by nitrogen levels (pooled data of 2 years)

Wheat genotype	Time from emergence (no. of days)		
	Anthesis	Physiological maturity	Grain-filling period
'VL 738'	190	230	40
'Shalimar Wheat 1'	187	235	48
'HS 240'	186	230	44
'HS 365'	188	235	47
Levels of nitrogen (kg/ha)			
N_0	190	226	36
N_{50}	188	231	43
N_{100}	186	234	48
N_{150}	187	235	48

of 'Shalimar Wheat 1' and 'HS 365' in terms of grain yield should have been at par to other genotypes. The grain yield and straw yield increased significantly with subsequent increase in nitrogen application up to 100 kg N/ha. However, straw yield irrespective of cultivars recorded increasing trend significantly up to 150 kg N/ha. At all the levels of nitrogen application wheat cultivars vary significantly with respect to grain yield (Table 4). However magnitude of difference was higher at lower levels. Except 'Shalimar Wheat 1' and 'HS 365' there was not significant increase in grain yield by increasing nitrogen application more than 100 kg N/ha. The superiority of 'Shalimar Wheat 1' and 'HS 365' over other genotypes was mainly due to more number of ears/m^2. Differential response of wheat cultivars to N levels may be attributed to variation in their genetic potential.

Nitrogen uptake and nitrogen-use efficiency

The nitrogen uptake (grain and straw) were significantly influenced by the dose of nitrogen applied (Table 1). 'Shalimar Wheat 1' recorded more total N uptake (kg/ha) in grain, followed by 'HS 365', 'HS 365' and 'VL 738' and recorded higher N uptake in straw over the other genotypes. The N uptake increases with subsequent increase in N application but at decreasing rate. However, there was no significant increase in N uptake (both in grain and straw) by increasing nitrogen application above 100 kg N/ha. The nitrogen harvest index was more than wheat harvest index irrespective of cultivars and nitrogen levels, indicating that proportion of nitrogen partitioned to grains at maturity exceeded the proportion of drymatter, which partitioned to grains. Agronomic efficiency (AE), physiological efficiency (PE) and N recovery efficiency (RE) decreased with increasing N rate among all the cultivars. However magnitude of decrease increased with subsequent increase in N application. The AE, PE and RE were from 11.6~27.2 kg/ha, 55.6~57.6 kg/kg and 21.1~47.6% in VL 738; 12.2~28.8 kg/kg, 57.07~58.86 kg/kg and 21.93~50% in 'Shalimar wheat 1'; 11.4~56.52 kg/kg, 55.2~57.14 kg/kg, and 20.26–53% in 'HS 240' and 12.9~31.2 kg/kg, 56.25~58.41 kg/kg and 22.6 53% in 'HS 365'. Efficiency of N uptake and N utilization in the production of grain requires that those processes associated with the absorption, translocation, assimilation and redistribution of N operate efficiently. The difference in N uptake and indices of nitrogen-use efficiency of wheat cultivars may be due to several factors. These factors may include root morphology and extension, biochemical and physiological mechanisms in nitrate assimilation and their usage (Golik *et al.* 2005). The high yielding ability of the efficient genotypes under stressful conditions of N shortage was associated with the formation of strong sinks in the regenerative organs (Simonetta *et al.* 2009).

Response analysis

Application of N induced a linear increase in the beginning but with further increase in levels of N subsequent increase in yield was at decreasing rate as a result of which genotypes recorded quadratic response to N application. The N-use response was obviously better in 'Shalimar Wheat 1' and 'HS 365' compared to other cultivars. (Fig 1). The observed and predicted yield of different genotypes followed the same trend. The maximum nitrogen dose response calculated in genotypes 'VL 738', 'Shalimar Wheat 1', 'HS 240' and 'HS 365' was 118, 125, 123 and126.62 kg/ha, respectively whereas optimum economic dose of nitrogen for these genotypes was 115.31, 122.35, 119.61 and 122.89 kg/ha

Table 3 Relative economics of wheat genotypes as influenced by nitrogen levels (pooled data of 2 years)

Wheat genotype	Nitrogen levels (kg/ha)							
	0		50		100		150	
	Net profit	Benefit: cost ratio	Net profit	Benefit: cost ratio	Net profit	Benefit: cost ratio	Net profit	Benefit: cost ratio
'VL 738'	1,420	1.02	15,178	1.70	19,511	1.88	19,114	1.84
'Shalimar Wheat 1'	2,760	1.13	21,757	2.01	27,163	2.25	28,519	2.22
'HS 240'	1,581	1.07	14,413	1.67	17,614	1.79	19,303	1.85
'HS 365'	1,635	1.08	17,176	1.79	23,284	2.05	24,422	2.01

Wheat Rs 850/100 kg and N Rs11.96/kg

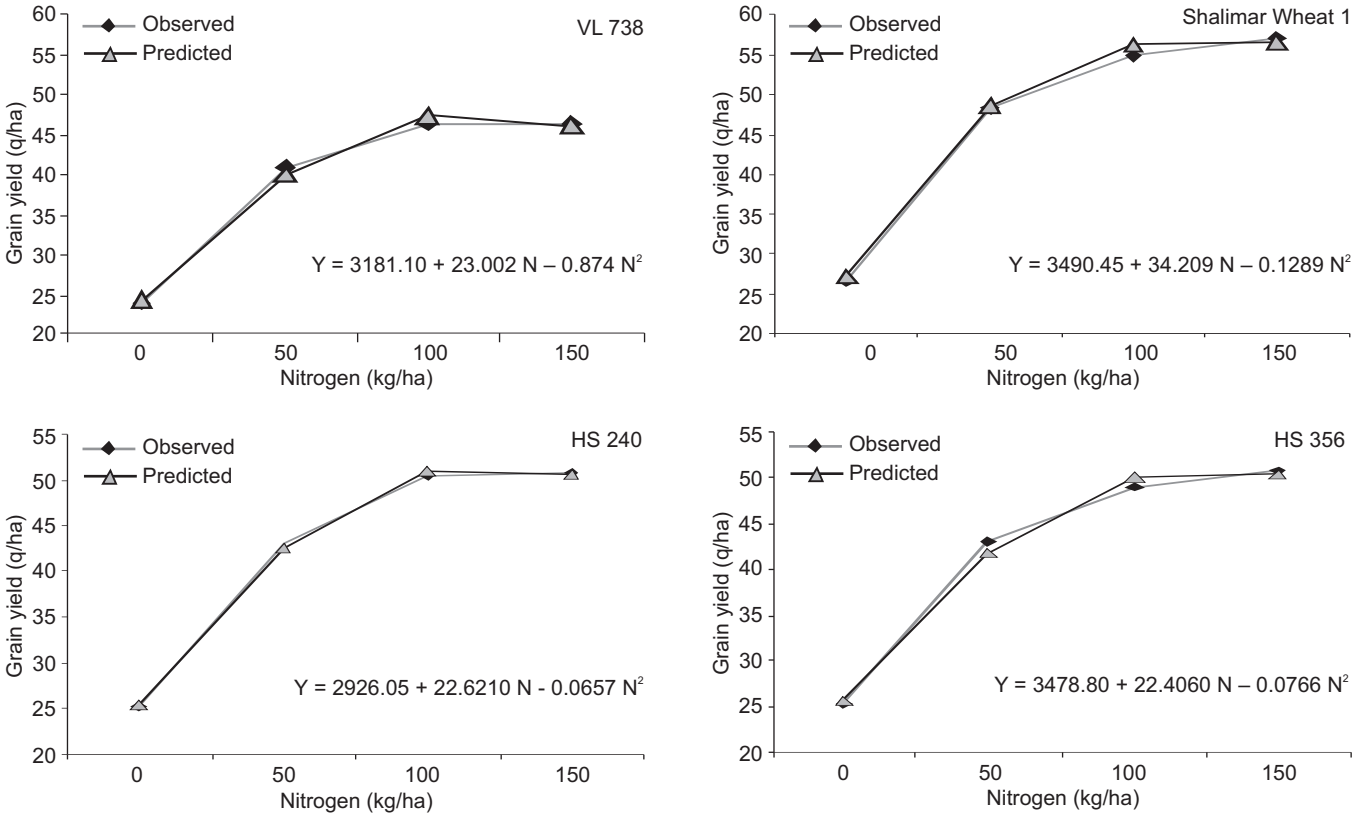

Fig 1 Observed and predicted yields of different wheat genotypes as influenced by nitrogen levels

respectively. This further supported the efficient N utilization of 'Shalimar Wheat 1' and 'HS 365'. The recovery efficiency can be greatly increased by reducing N rates below optimum dose but yield gets sacrificed. The differential response of wheat genotypes to nitrogen levels was also reported by Kalita and Nair (2001).

Phenological studies

Wheat genotypes showed differences in the number of days required to reach anthesis, maturity and grain-filling period. (Table 2). 'Shalimar Wheat 1' and 'HS 365' took higher number of days for grain filling resulting less sterility. Nitrogen levels also affected the crop phonological phases from anthesis to maturity. Low N content or deficiency can speed up the time, the plants require reaching maturity and thus can decrease the grain-filling period (Marschner 1995). Grain filling period is very important, when the grain-filling period is longer, this leads to higher yields and also to better quality (Yau 2007).

Relative economic analysis

The net profit increases with subsequent increase in levels of nitrogen in all the genotypes, however benefit : cost ratio shows increasing trend up to application of 100 kg N/ha only (Table 3). Thereafter the increasing nitrogen level resulted in reduced benefit : cost ratio except 'Shalimar Wheat 1'.

Table 4 Interaction effect of nitrogen levels and wheat genotypes on grain yield, nitrogen-use efficiency indices of wheat cultivars

Genotype	Grain yield (kg/ha)				Agronomic efficiency (kg grain/kg applied nitrogen)			Physiological efficiency(kg grain/kg nitrogen uptake)			N- recovery efficiency(%)		
Nitrogen levels (kg/ha)	0	50	100	150	50	100	150	50	100	150	50	100	150
'Shalimar Wheat 1'	2.78	4.22	4.54	4.61	30.8	17.6	12.8	58.86	57.41	56.62	50	31.2	21.93
'VL 738'	3.28	4.64	4.96	5.03	27.2	16.8	11.6	57.14	56.0	55.20	47.6	30	21.13
'HS 240'	2.60	4.15	4.47	4.53	26.52	16.5	11.4	57.6	57.66	57.05	53	32.6	22.66
'HS 356'	3.07	4.40	4.72	4.78	31.2	18.8	12.9	58.41	57.09	57.25	45.4	28.9	20.26
CD (*P*=0.05)	N × G 0.078												

'Shalimar Wheat 1' was found more profitable, followed by 'HS 365'.

It is concluded that there was no effect on yield by increasing N doses application more than 100 kg/ha in all the wheat genotypes except 'Shalimar Wheat 1'. The optimum economic dose of nitrogen for 'VL738', 'Shalimar Wheat 1', 'HS 240' and 'HS 365' were 115.31, 122.35, 119.61 and 122.89 kg/ha, respectively. This is mainly due to sink limitations. 'Shalimar Wheat 1' was found more economical under existing agroclimatic conditions and shows response even more than 100 kg N/ha. Also it would be worthwhile that improved cultivars should be bred which could be responsive to higher fertilizer dosages, especially of nitrogen so that wastage of nitrogen could be minimized and higher yield are realized.

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