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RESPONSE OF DUAL PURPOSE BARLEY TO RATES AND METHODS OF NITROGEN APPLICATION

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ABSTRACT

In winter months the forage availability for livestock reduces very much, thus barley can be used as dual purpose crop. In the present study the influence of different levels and methods of nitrogen application were tested against the dual purpose barley. The experiments were conducted at Botanical Garden-Azakhel, University of Peshawar during 2010 by using RCB design with split plot arrangement. Different nitrogen levels (40 kg ha^{-1}, 80 kg ha^{-1} and 120 kg ha^{-1}) were used. 40 kg ha^{-1} N showed minimum days to emergence, maximum spike m^{-2} and 1000 grains weight. 80 kg ha^{-1} N yielded maximum fresh and dry biomass, grains spike^{-1} and minimum days to spike while 120 kg ha^{-1} N showed maximum emergence m^{-2}, tillers plant^{-1}, leaves plant^{-1}, tillers m^{-2}, plant height and minimum days to maturity. N levels were applied either at once or divided in two and three equal doses. Nitrogen applied at once showed minimum days to emergence and maximum plant height while N applied in three divided doses yielded good results with maximum emergence m^{-2}, fresh and dry biomass, tillers and leaves plant^{-1}, tillers and spike m^{-2}, grains spike^{-1}, 1000 grains weight and minimum days to spike and maturity.

Keywords: barley, dual purpose, nitrogen application.

INTRODUCTION

Barley (*Hordeum vulgare* L., Family Poaceae) is an annuals plant with culm up to 70 cm high; leaf-blade 5-16 cm long, 4-8 mm wide and sometimes sparsely hairy. Rachis are tough and not breaking up at maturity. Barley was one of the most important food crops during the ancient world and is mentioned in the Holy Quran and in the Bible. Today its major utility as food crop has reduced but it is still used as fodder crop throughout the world. Many researchers have worked out the dual purpose plants i.e., Yau *et al*., (1989) stated that single grazing at the tillering stage reduced both grain and straw yield of barley. Torbert *et al*., (2001) reported that yield and yield component of maize were increased by increasing the rate of applied nitrogen. El-shatnawi and Makhadmeh (2002) studied seedling growth and development of wild oat and dual-purpose barley in pots and under field conditions. Arif *et al*., (2006) worked on the dual purpose wheat and found that non-cut plots produced significantly more spikes, grains spike^{-1}, grain weight, grain yield and biological yield. Arzadun *et al*., (2006) observed in winter wheat that 3-cm clipping height yielded 21% more forage than clipping at 7 cm height. Dang *et al*., (2006) reported that fertilizer application increased grain yield of wheat over control. Cheema *et al*., (2010) found that timing of N applications significantly affected the growth performance of wheat. Khalil *et al*., (2011) studied wheat as dual-purpose crop under different seed rates (S) and nitrogen (N) levels and found that grain yield decreased with delayed in chipping, while no cutting produced tallest plants with highest grain yield, tiller plant^{-1}, number of grains spike^{-1} and 1000-seed wieght. Jan *et al.,* (2011) stated that efficient nitrogen (N) fertilizer management is critical for the improved production of wheat through source and timing of N application.

MATERIALS AND METHODS

The experiment was conducted on local barley variety during winter 2010 at Botanical Garden-Azakhel, University of Peshawar to study the effect of different N levels and their timing (methods) of application on barley. A randomized complete block (RCB) design with split plot arrangement was used. The plot size was 3 x 5 m and seeds of barley were sown @ 100 kg ha^{-1} in each plot with 10 rows 5 m long and 30 cm apart. Phosphorus was applied @ 90 kg ha^{-1} in the form of SSP as basal dose. 1st irrigation was done at the time sowing and then after application 2nd and 3rd doses. Three levels of nitrogen viz: 40 kg ha^{-1}, 80 kg ha^{-1} and 120 kg ha^{-1} were applied using the following three methods of application. In 1st method all the three levels of nitrogen were applied in total to the respective plots once at time of sowing of seeds. In 2nd method the three levels of nitrogen were divided into two equal doses. One dose was applied at sowing and second at tillering stage. In third method the three levels of nitrogen were divided into three equal doses. One dose was applied at sowing, second at tillering and third at booting stage. All the standard agronomic practices were uniformly adopted for the experiment. All the data were statistically analyzed using program MSTAT-C (Freed and Eisensmith, 1986).

RESULTS AND DISCUSSIONS

Days to emergence

Days to emergence are recorded in Table-1. Different rates and methods of nitrogen applications both significantly affected the days to emergence. The N x M interaction and replication effects were insignificant. Nitrogen when applied in one dose recorded minimum (13.78) days to emergence for all the three levels of N, thus reducing the emergence period. When nitrogen application was done in two divided doses, the emergence period was (14.22). Treatments with three doses prolonged the days to emergence (15). Similarly, 40 kg ha $^{-1}$ N reduced the days to emergence to minimum (13.33) with all the three methods of application. At 80 kg ha $^{-1}$ N it was (14.78) with all the methods and with 120 kg ha $^{-1}$ N treatment had maximum days to emergence (15) with all methods of N application. Khalil *et al*., (2011) suggested that increase in nitrogen concentration reduced the days to emergence of seedlings in wheat. This opposes our findings as increase in N concentration to 120 kg ha $^{-1}$ increased the days to maximum as were minimum at 40 kg ha $^{-1}$. Arif *et al*., (2010) stated that maize plots with N @ 160 kg ha $^{-1}$ germinated in maximum days while plots with N @ 60 kg ha $^{-1}$ took minimum days. Similarly N applied at once at the time of sowing germinated earlier. This findings are in line with our results.

Table-1. Effect of methods of applying different nitrogen levels on days to emergence of seeds of barley. Each value has three replicates.

Treatments (kg ha $^{-1}$)	Methods of applying N			
	M1 (applied at once)	M2 (applied in two doses)	M3 (applied in three doses)	Mean
N1 (40)	12.67	13.00	14.33	13.33 b
N2 (80)	14.67	14.67	15.00	14.78 a
N3 (120)	14.00	15.00	15.67	14.89 a
Mean	13.78 b	14.22 ab	15.00 a	14.33

LSD Value for nitrogen application = 0.9044 at α 0.05
LSD Value for methods of nitrogen application = 0.9044 at α 0.05

Emergence m $^{-2}$

Different levels and methods of nitrogen applications and N x M interaction all have insignificant effects on emergence m $^{-2}$ (Table-2). However, nitrogen applied in three divided doses gave maximum seedlings (276) emergence m $^{-2}$. It was followed by (252.33) nitrogen applied in one dose. The minimum seedlings (229) emergence m $^{-2}$ was obtained when nitrogen was applied in two divided doses. Application of 120 kg ha $^{-1}$ nitrogen provided maximum seedlings (289.11) emergence m $^{-2}$, followed (241.89) by 40 kg ha $^{-1}$ nitrogen application and 80 kg ha $^{-1}$ nitrogen application (226.33). The results indicates that increase in N levels and applied in three divided doses increased the emergence m $^{-2}$. The same findings were obtained by Khalil *et al.*, (2011) that increase in nitrogen concentration produced more seedlings emergence in wheat.

Table-2. Effect of methods of applying different nitrogen levels on emergence of seedlings m $^{-2}$ of barley. Each value has three replicates.

Treatments (kg ha $^{-1}$)	Methods of applying N			
	M1 (applied at once)	M2 (applied in two doses)	M3 (applied in three doses)	Mean
N1 (40)	171.67	237.33	316.67	241.89
N2 (80)	291.00	156.67	231.33	226.33
N3 (120)	294.33	293.00	280.00	289.11
Mean	252.33	229.00	276.00	252.44

Number of tillers plant $^{-1}$

In Table-3 it was seen that different levels and methods of nitrogen applications and N X M interaction and replications all were non significant. However, nitrogen applied in three divided doses provided maximum number of tillers plant $^{-1}$ (15). Single dose nitrogen treatment provided (14.49) and two divided dose treatment gave (13.09) tillers plant $^{-1}$. With 120 kg ha $^{-1}$ maximum tillers plant $^{-1}$ (15.09) were obtained. It was followed by 40 kg ha $^{-1}$ (14.31) and 80 kg ha $^{-1}$ (13.18) treatments. Our results indicated that foliar application of nitrogen increased number of tillers plant $^{-1}$. Similar results also reported by Ling and Silberbush (2002), Siddiqui *et al*., (2008) and Otteson *et al*., (2007 and 2008) that increase in N levels increased the number of tillers plant $^{-1}$ in different plants. Similarly N applied in three divided doses produced maximum tillers plant $^{-1}$.

Number of leaves plant $^{-1}$

It was seen that different levels and methods of nitrogen applications and N x M interaction were insignificant (Table-4). However, maximum number of leaves plant^{-1} (77) and minimum (68.62) were obtained in treatments with three divided and single dose, respectively. Treatment with two divided doses yielded (76.47). Similarly, maximum number of leaves^{-1} (78.31), followed by (72.51) were recorded in 120 and 40 kg ha^{-1} nitrogen. 80 kg ha^{-1} nitrogen yielded minimum (71.27) leaves plant^{-1}. Khalil *et al*., (2011) suggested that the increase in N levels increased leaves plant^{-1} in wheat. But our findings are not similar as increase in N (120 kg ha^{-1}) reduced the number of leaves plant^{-1}. The N applied in three divided doses yielded maximum leaves plant^{-1}. This may be due to in fact that the plants got nitrogen at different stages may produce more foliage than applied as once.

Table-3. Effect of application methods of different nitrogen levels on number of tillers plant^{-1} of barley. Five plants from each replicate were randomly selected.

Treatments (kg ha^{-1})	Methods of applying N			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	12.80	13.87	16.27	14.31
N2 (80)	15.00	11.20	13.33	13.18
N3 (120)	15.67	14.20	15.40	15.09
Mean	14.49	13.09	15.00	14.19

Table-4. Effect of methods of applying different nitrogen levels on number of leaves plant^{-1} of barley. Five plants from each replicate were randomly selected.

Treatments (kg ha^{-1})	Methods of applying N			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	66.33	73.20	78.00	72.51
N2 (80)	79.87	59.13	74.80	71.27
N3 (120)	83.20	73.53	78.20	78.31
Mean	76.47	68.62	77.00	74.03

Number of tillers m^{-2}

Table-5 suggests that different N levels have significantly affected the number of tillers m^{-2}. The methods of nitrogen applications and N x M interaction had no significant effect on number of tillers. Nitrogen applied in three equal doses produced maximum number of tillers (180.56), while nitrogen applied in two divided doses were next (152.22) and treatment with single total dose reduced the number of tillers (149.11). When applied nitrogen was at 120, 80 and 40 kg ha^{-1} the number of tillers were 191, 168.22 and 122.67 respectively. Bakht *et al*., (2010) suggested that 120 kg ha^{-1} N applied in three divided doses produced maximum tillers m^{-2} in wheat varieties. Similar results were also recorded by Siddiqui *et al*., (2008) and Otteson *et al*., (2007 and 2008). Our findings are also in line with their results. It may be due to the fact that nitrogen is an essential element for growth and development and thus promoted the vegetative growth.

Table-5. Effect of methods of applying of different nitrogen levels on number of tillers m^{-2}. Each value has three replicates.

Treatments (kg ha^{-1})	Methods of applying N			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	118.00	119.33	130.67	122.67 b
N2 (80)	195.33	122.00	187.33	168.22 ab
N3 (120)	134.00	215.33	223.67	191.00 a
Mean	149.11	152.22	180.56	

LSD Value for nitrogen application = 53.26 at α 0.05

Plant height

The data on plant height of barley is presented in Table-6, which indicates that different N treatments significantly affected the plant height, while methods of nitrogen applications and N x M interaction were non significant. The height was 47.51, 45.20 and 44.29 when nitrogen was applied in single, three divided and two divided doses respectively. Application of nitrogen @ 120, 80 and 40 kg ha^{-1} gave 47.67, 45.53 and 43.80 plant heights, respectively. Taller plants were recorded in high N treatments (Ling and Silberbrush, 2002; Bakht *et al*., 2010). These findings are agreed with our results. The probable reason could be more vegetative growth at highest dose of nitrogen which could have resulted in taller plants.

Table-6. Effect of methods of applying different nitrogen levels on plant height (cm) of barley. Five plants from each replicate were randomly selected.

Treatments (kg ha^{-1})	Methods of applying N			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	42.87 cd	45.00 abc	43.53 cd	43.80
N2 (80)	49.67 a	38.87 d	48.07 abc	45.53
N3 (120)	50.00 a	49.00 ab	44.00 bcd	47.67
Mean	47.51	44.29	45.20	45.67

LSD Value for N x M interaction = 5.437 at α 0.05

Number of days to spike

Different N levels, methods of N application and N x M interaction all significantly affected the number of days to spike (Table-7). Total nitrogen applied in single dose reduced days to spike to (124.44). It was followed by treatment with two doses (126.89) and three divided doses took maximum days to spike (128.11). 80 kg ha^{-1} nitrogen application reduced days to spike to (125.11). Next was 40 kg ha^{-1} nitrogen application with (126.33) days and 120 kg ha^{-1} applied nitrogen took maximum days to spike (128). The N2 X M3 interaction reduced the days to spike to minimum (122.33) while N3 x M1 interaction prolonged the days to spike to maximum (129.67).

Number of spikes m^{-2}

The results in Table-8 revealed that different levels and methods of nitrogen applications and N x M interaction had insignificant effect on the number of spikes m^{-2}. Nitrogen applied in three doses produced maximum number of spikes m^{-2} (222.67), while nitrogen applied in single dose at all gave (189.44) and nitrogen applied in two divided doses had minimum number of spikes m^{-2} (166.33). The number of spikes m^{-2} was 263.67, 216, and 188.33 with 40, 80 and 120 kg ha^{-1} kg ha^{-1} N fertilization, respectively.

Table-7. Effect of method of applying different nitrogen levels on days to spikes of barley. Each value has three replicates.

Treatments (kg ha^{-1})	Methods of applying N			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	129.00 ab	124.00 de	126.00 bcd	126.33 ab
N2 (80)	125.67 cd	127.33 ab	122.33 e	125.11 b
N3 (120)	129.67 a	129.33 a	125.00 cde	128.00 a
Mean	128.11 a	126.89 a	124.44 b	126.48

LSD Value for nitrogen application = 1.872 at α 0.05
LSD Value for methods of N application = 1.872 at α 0.05
LSD Value for N x C interaction = 3.242 at α 0.05

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Table-8. Effect of method of applying different nitrogen levels on number of spikesm^{-2} of barley. Each value has three replicates.

Treatments (kg ha^{-1})	**Methods of applying N**			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	142.67	177.00	263.67	194.44
N2 (80)	205.67	141.67	216.00	187.78
N3 (120)	220.00	165.33	188.33	191.22
Mean	189.44	161.33	222.67	191.15

Days to maturity

Different levels and methods of nitrogen application and N x M interaction had significant affect on the days to maturity (Table-9). Application of nitrogen in three divided doses, two divided doses and single dose respectively gave 165.67, 171.44 and 177.89 days to maturity. The application of 120, 80 and 40 kg ha^{-1} nitrogen, respectively took 169.56, 170.89 and 174.56 days to maturity. The N3 x M2 interaction took minimum days to maturity (163.67), while N1 x M1 interaction prolonged the days to maturity to 183.33. Siddiqui *et al*., (2008) and Bakht *et al*., (2010) recorded that increase in N levels and applied in three divided doses reduced the days to maturity and suggested that foliar application of N significantly increased the growth characteristics. Similar results were obtained in our experiment.

Table-9. Effect of methods of applying different nitrogen levels on days to maturity (spikes maturity) of barley. Each value has three replicates.

Treatments (kg ha^{-1})	**Methods of applying N**			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	183.33 a	177.33 b	173.00 c	177.89 a
N2 (80)	172.33 c	171.67 c	170.33 cd	171.44 b
N3 (120)	168.00 de	163.67 f	165.33 ef	165.67 c
Mean	174.56 a	170.89 b	169.56 b	171.67

LSD Value for nitrogen application = 1.786 at α 0.05
LSD Value for methods of N application = 1.786 at α 0.05
LSD Value for N x M interaction= 3.093 at α 0.05

Grains spike^{-1}

The results indicated that different levels and methods of nitrogen application and N x M interactions had non significant effect on grains spike^{-1} (Table-10). Maximum grains spike^{-1} (41.09) were produced by treatments with two divided doses of nitrogen. There were 41.04 grains spike^{-1} with three divided doses while single dose of nitrogen gave minimum grains spike^{-1} (39.47). Furthermore, 80, 40 and 120 kg ha^{-1} respectively yielded 42.16, 39.84 and 39.60 grains spike^{-1}. Bakht *et al*., (2010) and Khalil *et al*., (2011) recorded that increase in N levels increased the number of grains spike^{-1} in wheat. These findings are not in favor of our results as maximum grains were produced in treatments with 40 kg ha^{-1} N and when N increased to 120 kg ha^{-1} resulted decrease in grains spike^{-1}. Nitrogen at once produced minimum grains while nitrogen in two doses produced maximum grains spike^{-1}. Hossain *et al*., (2003) recorded that increase in N levels increased the grains spike^{-1} up to some extend but further increase did not affect the grains spike^{-1}. Similar results were obtained in our experiment.

Table-10. Effect of methods of applying different Nitrogen concentrations on no. grains spike^{-1} of barley. Five plants from each replicate were randomly selected from each of three replicates.

Treatments (kg ha^{-1})	**Methods of applying N**			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	41.80	36.13	41.60	39.84
N2 (80)	36.13	47.73	42.60	42.16
N3 (120)	40.47	39.40	38.93	39.60
Mean	39.47	41.09	41.04	40.53

1000 grains weight

It was recorded that different levels and methods of nitrogen application and N x M interactions had insignificant effect on 1000 grains weight (Table-11). Thousand grains weights were 41.78, 40.89 and 40.03 respectively when nitrogen was applied in three equal doses, two and single doses. The maximum 1000 grains weight (45.07) was obtained by 40 kg ha^{-1} N treatment, which was fallowed by 120 and 80 kg ha^{-1} of nitrogen treatment, respectively producing 41.57 and 38.70 weights of 1000 grains. Increase in N levels increased the 1000 grains weight in maize (Akmal *et al*., 2010) and Khalil *et al*., (2011) had the same findings. But our findings are against these results as increase in N levels decreased the 1000 seeds weight. All the levels when applied in three divided doses yielded maximum 1000 seeds weight.

Grain yield (kg ha^{-1})

It was recorded that methods of nitrogen application significantly effected while different levels and N x M interactions insignificantly affected grain yield of barley (Table-12). However, maximum grain yield (4606.67) was showed by nitrogen applied in three divided doses, it was followed by (3891.11) nitrogen applied at once. The minimum grain yield (3107.78) was yielded by nitrogen applied in two doses. N applied @ 40 kg ha^{-1} gave maximum grain yield (4137.778) which was followed by 120 and 80 kg ha^{-1} of nitrogen treatment respectively producing 3834.44 and 3633.33 seed yield kg ha^{-1}. All the levels when applied in three divided doses gave maximum grain yield. Zeidan and Amany (2006) and Arif *et al*., (2010) found that different methods of nitrogen application had significant effect on grain yield and nitrogen applied in three doses provided maximum grain yield. These results are in line with those of our findings.

Table-11. Effect of methods of applying different nitrogen levels on thousand grains weight (gm) of barley. Each value has three replicates.

Treatments (kg ha^{-1})	**Methods of applying N**			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	40.83	42.67	45.07	42.86
N2 (80)	41.97	37.03	38.70	39.23
N3 (120)	39.87	40.40	41.57	40.61
Mean	40.89	40.03	41.78	40.90

Table-12. Effect of methods of applying different nitrogen levels on seed yield (kg ha^{-1}) of barley. Each value has three replicates.

N levels (kg ha^{-1})	**Methods of applying N**			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	3006.667	4286.667	4380.000	4137.78
N2 (80)	3496.667	2503.333	3323.333	3633.33
N3 (120)	5910.000	4110.000	3800.000	3834.44
Mean	3891.11 ab	3107.78 b	4606.67 a	

LSD Value for methods of N application = 1037 at α 0.05

Biological yield (kg ha^{-1})

Different rates and methods of nitrogen application and N x M interaction all have significantly the biological yield (kg ha^{-1}) (Table-13). Increase in N levels significantly enhanced the biological yield (kg ha^{-1}) as nitrogen @ 120 kg ha^{-1} yielded maximum (11642.78) biological yield followed by 80 kg ha^{-1} (9392.22). Minimum (7224.11) biological yield was provided by N @ 40 kg ha^{-1}. The methods of application of N also significantly increased the biological yield (kg ha^{-1}). The nitrogen applied at once gave minimum (7596.11) biological yield followed by N applied in two doses (9853). The nitrogen applied in three equal doses provided maximum (10810) biological yield. The N1 x M3 interaction provided maximum (13570) biological yield (kg ha^{-1}). Our results are in line with those of Noy-Meir and Briske (2002), Iqtidar *et al*., (2006) and Khalil *et al*., (2011) who recorded that increase in N levels increased the biological yield.

Table-13. Effect of methods of applying different nitrogen levels on biological yield (kg ha^{-1}) of barley. Each value has three replicates.

Treatments (kg ha^{-1})	**Methods of applying N**			
	M1 (applied at once)	**M2 (applied in two doses)**	**M3 (applied in three doses)**	**Mean**
N1 (40)	1126.667 c	8091.667 b	13570.000 a	7224.111 b
N2 (80)	9155.667 b	10056.667 ab	10346.667 ab	9392.222 ab
N3 (120)	11390.000 ab	10028.333 ab	11011.667 ab	11642.778 a
Mean	7596.111 b	9853.000 ab	10810.000 a	

LSD Value for nitrogen application = 2273 at α 0.05
LSD Value for methods of N application = 2273 at α 0.05
LSD Value for N x M interaction= 3938 at α 0.05

CONCLUSIONS

The present study indicates that timing of nitrogen application significantly affected the dual purpose barley and nitrogen applied in three divided doses increased the biological yield (kg ha^{-1}), grain yield (kg ha^{-1}) and reduced the days to maturity and spike.

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