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Yield and Quality of Barley Grain as Influenced by Nitrogen Application

M. Ayub, I. A.P. Dewi* and A. Tanveer
Department of Agronomy, University of Agriculture, Faisalabad, Pakistan
*School of Agriculture and Forest Sciences, University College of North Wales, Bangor, U.K.

Abstract

A pot experiment was conducted to evaluate the effect of nitrogen levels (0, 50, and 100 kg ha^{-1}) on grain yield, yie components and quality of barley grain. Grain yield was increased progressively with nitrogen application up to 100 kg ha Higher grain yield with nitrogen application was related to higher number of fertile tillers, number of grains per spike a 1000-grain weight. 50 and 100 kg N ha^{-1} gave significantly lower grain crude protein percentage both in grain and stra than 0 kg N ha^{-1}. Modified acid detergent fibre percentage of straw and grain was not affected by the application nitrogen.

Introduction

Cereals are grown throughout the world for production of grain for both animal and human consumption. Due to the increasing world population, the demand for cereals is likely to increase to 2.4 billion tons by the year 2000 (Aziz, 1977).

Among the various agronomic factors that may affect the yield and quality of grain, the application of nitrogen is considered to be the most important (Tofinga, 1990). Lauer and Partridge (1990) found that each kg of N applied to the soil from 0-202 kg ha^{-1} increased barley grain yield by 7 kg ha^{-1}. Clancy *et al.,* (1991) reported that N rate of 90 kg ha^{-1} increased the grain yield of barley by 17 and 5 per cent in 1986 and 1987 respectively. Zebarth and Sheared (1991) reported that increases in the rate of applied N were accompanied by a linear increase in grain weight. However, Clancy *et al.,* (1991) reported that increasing N application rate did not effect grain weight. An increase in the amount of N results in a grater number of tillers and grain number per ear (Conry, 1991; Clancy *et al.*, 1991).

An increase in the grain protein content of barley following N application has been reported by Clancy *et al.* (1991). Nitrogen levels ranging from 0-400 kg ha^{-1} did not affect the ADF (Acid Detergent Fibre) and NDF (Neutral Detergent Fibre)of grass harvested on the same date (Davis *et al.*, 1987) and barley harvested at the soft dough stage (Dirienzo *et al.*, 1991). Ziolek and Szmigiel (1982) observed a decrease in the crude fibre content of maize following the application of N.

Bulman and Smith (1993) reported that grain yield of barley was increased with nitrogen application due to an increase in number of spikes m^{-2}, 1000-grain weight and grains per spike. Baethgen *et al.* (1995) reported that nitrogen fertilizer application increased the number of tillers per m^{-2}, number spikes m^{-2}, number of grains per spike and grain yield. Kernel weight was the yield component that responded least to nitrogen fertilizer.

The objective of this experiment was to assess, under pot conditions, the effect of three N fertilizer levels on barley grain yield, yield components and chemical composition.

Materials and Methods

The experiment was carried out at the University Colle Farm, Aber, Gwynedd, UK. The barley variety Atem w sown in first week of December and terminated on last d of May. The experiment was carried out in a glasshou with no temperature control and without supplementa heating.

The experiment was sown in 23 cm X 23 cm plastic po painted black on the outer sides. Each pot had a h drilled at the bottom for drainage. Nitrogen w broadcasted at the rate of 0, 50 and 100 kg ha^{-1} to t appropriate pots in first week of January. Barley w planted at a seed rate equivalent to 180 kg ha^{-1}. Havi determined average seed weight, 24 seeds were required each pot, arranged in four rows of six plants. The crop w sown at a distance of 3.8 cm from row to row and plant plant. Seeds of barley were sown at a depth of 4 cm. T seeds were sown at each position within the pot a thinned, where necessary, to one plant per site af germination. The pots were watered once or twice a we Before sowing soil was analyzed. It had a pH of 6.2, content 21 ppm, K content 112 ppm, N content 0.11 p cent and an organic matter content of 5.1 per cent.

The experiment was arranged as a randomized compl block design with three replicates. Each block was o separate bench in the glasshouse. 80 kg phosphorus and kg/ha potassium were applied to the experiment bef sowing.

Plant samples were analyzed for total nitrogen using kjeldahl method (AOAC, 1984) with a Kjeltec Auto 10 Analyser. The samples were digested using a bl digester-Tecam DG-1. Nitrogen content was then multip by 6.25 to calculate crude protein percentage. MADF cent was determined using a fibrotic system M-Teca consisting of a hot extractor (1020) and cold (10 extractor (AOAC, 1984).

The data collected from experiment were subjected statistical analysis, using analysis of variance. Where treatments effects were found to be significant (P<0. treatment means were compared using LSD test at 5 cent probability level (Steel and Torrie, 1984).

Climatic conditions: Mean maximum and minimum temperature and sunshine hours during the growth period are given in Table 1. Maximum and minimum air temperature was recorded in the glasshouse and bright sunshine hours were recorded at a weather station located at a site about 1 km from the glasshouse. Monthly sunshine hours ranged from 0.9 to 8.0, while mean daily temperature each month ranged between 6.2 to 12.9°C during the period of the experiment.

Table 1: Mean monthly maximum, minimum and mean temperature and sunshine hours December to May.

Months	Maximum temp(°C)	Minimum temp(°C)	Mean temp(°C)	Sunshine hours
December	8.5	3.9	6.2	1.3
January	11.5	4.2	7.9	0.9
February	11.3	3.7	7.5	1.6
March	12.0	5.8	8.9	1.6
April	11.6	4.9	8.3	5.8
May	16.0	9.4	12.9	8.0

Results

Fertile tillers/m^2: Table 2 shows that the number of fertile tillers increased significantly ($P<0.05$) between each level of nitrogen application. 100 kg N ha^{-1} gave the highest number of tillers. Compared to 0 kg N ha^{-1}, the application of 50 kg N ha^{-1} increased the number of fertile tillers by 189 (43%) and 100 kg N ha^{-1} increased the number of fertile tillers by 365 (83%).

Number of grains/spike: The number of grains per spike was affected significantly ($P<0.05$) by nitrogen levels. Zero kg N ha^{-1} produced significantly ($P<0.05$) lower grains per spike than both 50 and 100 N ha^{-1}, but 50 and 100 kg N ha^{-1} produced the same number of grains per spike Table 2.

1000-Grain weight (g): 1000-grain weight increased (Table 2) with increasing nitrogen rate from 38.4 g to 43.4 g at 0 and 100 kg N ha^{-1} respectively. However, the differences in 1000-grain weight between treatments were not significant ($P<0.05$).

Grain yield (g m^{-2}): A significant ($P<0.05$) increase in grain yield was obtained following nitrogen application. Yield increased from 107.2 g m^{-2} at 0 kg N ha^{-1} to a maximum of 446.5 g m^{-2} at 100 kg N ha^{-1} (Table 2).

Grain crude protein and modified acid detergent fibre percentage: Crude protein percentage was significantly ($P<0.05$) affected by the application of nitrogen (Table 2). 0 kg N ha^{-1} gave significantly ($P<0.05$) higher crude protein percentage than both 50 Kg N ha^{-1} and 100 kg N ha^{-1}. The differences between 100 and 50 kg N ha^{-1} were not significant ($P<0.05$). The CP per cent varied from 10.57 where no nitrogen was applied to 7.21 where 50 kg N ha^{-1} was applied. The application of nitrogen fertilizer had no effect on grain MADF per cent which varied from 5.0 at 0 kg N ha^{-1} to 5.5 at 100 kg N ha^{-1}.

Straw crude protein and modified acid detergent fibre percentage: Table 2 shows that 0 kg N ha^{-1} gave significantly higher straw CP per cent than 50 and 100 kg N ha^{-1} which in turn were not significantly ($P<0.05$) different. The crude protein percentage varied from 2.3 at 0 kg nitrogen to 1.5 where 50 kg nitrogen was applied. Straw MADF per cent was not significantly ($P<0.05$) affected by the addition of nitrogen and it varied from 36.3 where 0 kg nitrogen was applied to 41.4 where 50 kg nitrogen was applied.

Discussion

Barley grain yield and yield components: Nitrogen increased the number of fertile tillers m^{-2} from 441.0 to a maximum of 806.4 m^{-2} which agree with published work of Conry (1991), Clancy *et al.* (1991) and Baethgen *et al.* (1995). They have found that increasing the supply of nitrogen increases tillers numbers. Whilst the number of fertile tillers increased with increasing N application rate, it should be noted that decreases in tiller number have been noted following application rates of 150 kg N ha^{-1}. There was a significant ($P<0.05$) increase in the number of grains per spike with increasing nitrogen application. Increases in the number of grains per spike with nitrogen application have been reported by Conry (1991), Clancy *et al.* (1991) and Bulman and Smith (1993). The number of grains were not increased when nitrogen rate was increased to 100 kg ha^{-1}. These findings contrast with those of Zebarth and

Table 2: Effect of nitrogen application on grain yield and yield components of barley.

Nitrogen rate (kg ha^{-1})	Fertile tillers (m^{-2})	No.of grains/ spike	1000-grain weight	Grain yield (g m^{-2})	Grain CP%	Grain MADF%	Straw CP%	Straw MADF%
0	441.0c	6.3b	38.4	107.2c	10.5a	5.0	2.3a	36.3
50	630.0b	12.9a	40.4	324.8b	7.2b	5.4	1.5b	41.4
100	806.4a	12.9a	43.4	446.5a	8.0b	5.5	1.7b	40.8
SED ±	48.26	0.55	N.S	25.46	0.33	N.S	0.6	N.S

N.S = Not significant.

Sheared (1991). They found a linear increase in the number of grains per spike up to 200 kg N ha^{-1}. This difference may be attributed to differences in the fertility status of the soil.

1000-grain weight was not significantly ($P<0.05$) affected by nitrogen application but an increase was observed up to 100 kg N ha^{-1}. Non-significant differences in grain weight following nitrogen application have been reported by several authors (Lauer and Partridge, 1990; Clancy *et al.*, 1991) and Baethgen *et al.* (1995). However, Zebarth and Sheared, (1991) and Bulman and Smith (1993) have reported that nitrogen application increased grain weight.

The amount of grain produced depends mainly on the number of tillers, the number of ears per plant, the weight per ear, the number of grains per ear and individual grain weight. Grain yield can be increased by increasing these parameters separately or in combination, but often when one parameter is increased, the others decrease. Grain yield increased from 107.2 g m^{-2} at 0 kg N ha^{-1} to a maximum of 446.5 g m^{-2} at 100 kg N ha^{-1}. Grain yield was positively correlated with fertile tillers ($r=0.99$), number of grains per ear ($r=0.93$) and 1000-grain weight ($r=0.96$). Since 1000-grain weight was not significantly ($P<0.05$) affected, yield was related mainly to tillers m^{-2} and grains per ear. The effect of 50 kg N ha^{-1} is through an increase in both tillers m^{-2} and grains per ear. But the extra yield from 100 kg N ha^{-1} was mainly due to an increase in tiller numbers. A linear relationship was found between grain yield and nitrogen rate ($r^2=0.97$), nitrogen and fertile tillers ($r^2=1$) and nitrogen rate and 1000-grain weight ($r^2=0.99$). These results suggest that the optimum rate for barley under the current experimental conditions would be greater than 100 kg N ha^{-1}. The increase in grain yield with nitrogen application is in agreement with results of Lauer and Partridge (1990), Clancy *et al.* (1991) and Bulman and Smith (1993) and Baethgen *et al.* (1995). Reductions in yield at higher rates of nitrogen application have been observed due to increased lodging and disease levels. In the present experiment, yield was increased significantly ($P<0.05$) up to the 100 kg N ha^{-1} indicating no adverse effect at these levels of nitrogen.

Grain crude protein content was significantly ($P<0.05$) influenced by nitrogen application. 50 and 100 kg N ha^{-1} gave a lower crude protein percentage than 0 kg N ha^{-1} which is not in agreement with the work of Clancy *et al.* (1991) where increases in grain protein content with increasing nitrogen rate have been reported. The decrease observed in the current experiment might be due to a dilution effect. Johnston and Fowler (1991) reported that the larger the increase in dry matter yield the greater the reduction in nitrogen concentration reflecting the dilution of nitrogen.

MADF per cent of straw and grain was not altered by th application of nitrogen. Dirienzo *et al.* (1991) have reporte similar results in grasses.

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