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Wheat Yield Components are Positively Influenced by Nitrogen Application under Moisture Deficit Environments

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ABSTRACT

A field experiment was carried out during 2002-2003 to investigate the response of wheat yield components to nitrogen application at the Agricultural Research Station of Gonbad, Iran with a mean annual precipitation of 453 mm. Subtropical wheat variety of Kohdasht was sown with four levels of nitrogen as no-nitrogen fertilization (N_0), net nitrogen of 30 (N_1), 60 (N_2) and 90 (N_3) kg ha^{-1} with four replications. Agronomic traits and yield components were positively influenced by nitrogen application. Increasing nitrogen from 60 to 90 kg ha^{-1} did not increase theses characteristics further. Based on simple models, the yield could be predicted under such environments that need further testing on large scale.

Key Words: Rainfed wheat; Nitrogen fertilization; Wheat yield components

INTRODUCTION

Winter wheat (*Triticum aestivum* L.), the most important food grain produced in Iran is grown on some 6 million ha (FAO, 2007). Northern Iran is one of the main regions for agriculture production. The optimum rate for nitrogen application has not been known for rainfed wheat in the Gonbad, Iran. Nitrogen fertilization enhances precipitation or irrigation-water-use efficiency (WUE). Previous findings indicated that nitrogen fertilization increased grain yield (Khaliq *et al*., 1999). Although WUE can be improved by nitrogen fertilization, but high N fertilization rates may result in excess biomass production using up stored soil water needed for grain production (Nielsen & Halvorson, 1991). Khaliq *et al*. (1999) reported that plant height, grains per spike, spikes per m^2 and grain yield increased with increasing nitrogen levels from 0 to 175 kg ha^{-1}. The soil moisture availability water and fertility status may influence many quality criteria and these may be of the greatest significant in wheat (Musick & Porter, 1990). Carr *et al*. (1992) reported that nitrogen fertilization significantly affect grain yield and protein content. Weston *et al*. (1993) concluded that nitrogen caused an increase in grain yield and grain protein content in spring barley. Danaei (1993) and Swarup and Sharma (1993) reported that the effect of nitrogen application on spike length was significant. Also, Several authors (Kumar & Agarwal, 1990; Lorzadeh, 1993; Swarup & Sharma, 1993; Ayoub *et al*., 1994; Khaliq *et al*., 1999) have reported direct relation between nitrogen application and plant height. Camberato and Bock (1990), Yazdi Samadi and Abdmishani (1991), Zebart and Sheard (1992), Danaei (1993), Ayoub *et al.* (1994) and Khaliq *et al*. (1999) found that nitrogen application affect spikes per m^2. Also, Ayoub *et al.* (1994), Malakouti and Nafisi (1994), Mossedaq and Smith (1994) and Shah *et al*. (1994) reported that increasing nitrogen application caused increase in grains per unite area.

Oad *et al*. (2004) reported that banding of 120 kg N ha^{-1} was better way to apply N fertilizers that resulted in higher yield and yield components of wheat. Maitlo *et al*. (2006) concluded that the integrated application of 75 kg N ha^{-1} and 2–2.5% foliar urea solution improved growth, yield, nutrient uptake and quality of wheat. Ali *et al.* (2003) found that productive tillers m^{-2}, 1000-grain weight and grain yield of wheat increased with the application of 150 kg N ha^{-1}. Whereas application of 175 kg N ha^{-1} resulted in the highest grains per spike and the highest plant height was obtained from applying 200 kg N ha^{-1}.

The objective of present study was to investigate effects of nitrogen application rates on yield components of rainfed wheat and to model some of these components as a function of nitrogen application rates.

MATERIALS AND METHODS

Field experiment was carried out during growing season of 2002-2003 at the Agricultural Research Station of Gonbad located at the north of Iran (37º 16´ N, 55º 12´ E;

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elevation 37.2 m), with a mean annual precipitation and relative humidity of 453 mm and 65%, respectively (Table I). The crop received 326 mm precipitation during growing season.

The field soil was silt loam. Average field capacity and bulk density were 25% and 1.4 g cm^{-3}, respectively. Electrical conductivity and pH were 0.73 dS m^{-1} and 8.1. The field soil had 0.15% total N, 15, 350, 2.6, 0.60 and 20 mg kg^{-1} P, K, Fe, Zn and B, respectively. Subtropical wheat (*Triticum aestivum* L.) variety of Kohdasht was sown on December in 2002 at seeding rate of 123 kg ha^{-1} in plots with 17 cm apart 12 rows and 5 m length (5 × 2.21 m^2). Four levels of nitrogen fertilization 90 (N_3), 60 (N_2) and 30 (N_1) kg ha^{-1} and no-nitrogen fertilization (N_0) were applied with four replications. Nitrogen was applied in three equal splits at planting, tillering and stem elongation stages. Phosphorus (P) at 100 kg ha^{-1} and potash (K) at 50 kg ha^{-1} were applied according to wheat requirement. Supplemental irrigation water with Ec of 1260 µS m^{-1} averaged 28 mm. Vegetative growth characteristics viz. plant height (PLH) and spike length (SL) and components such as: 1000-grain weight (TGW), grains per spike (GNS), grains per unit area (GNSM), grains per spikelet (GNST), spikes per unit area (SN1) and spikelets per spike (SNS) were measured in experimental plots. The data were analyzed statistically by analysis of variance techniques and the treatment means were compared by Duncan's multiple range tests. The least squares procedure was applied to develop linear and quadratic models (Moghaddam, 1999).

RESULTS AND DISCUSSION

Plant height. The nitrogen application significantly affected plant height ($P \leq 0.001$). The maximum (99.35 cm) and minimum (86.97 cm) were recorded for N_3 and N_0, respectively. Nitrogen increased PLH through elongation of internodes. Several authors (Kumar & Agarwal, 1990; Lorzadeh, 1993; Swarup & Sharma, 1993; Ayoub *et al.*, 1994; Khaliq *et al.*, 1999) have reported direct relation between nitrogen application and PLH. To describe the relationship between plant height and applied nitrogen, a model was worked out by regression analysis and the least squares procedure (Moghaddam, 1999). The obtained model reads as:

$$PLH = 87.131 + 0.265\,N - 0.001\,N^2 \quad R^2 = 0.99 \quad (1)$$

Where PLH and N are plant height (cm) and applied net nitrogen (kg ha^{-1}). The response was quadratic. The measured and predicted values versus net nitrogen were shown in Fig. 1.

Spike length. The effect of nitrogen application on spike length was significant ($P \leq 0.001$). This finding is consistence with those reported by Danaei (1993) and Swarup and Sharma (1993). The SL averaged as 10.1cm for N_0 treatment. The SL from three levels of 30, 60 and 90 kg ha^{-1} did not vary statistically.

Table I. Precipitation, relative humidity and air temperature during growth season of 2002–03

Months	Precipitation (mm)	Relative humidity (%)	Temperature (ºC)
November	47.5	79.0	8.0
December	46.1	76.3	8.2
January	45.6	72.3	8.6
February	62.6	77.3	8.5
March	75.1	82.0	9.7
April	40.3	77.7	13.9
May	23.3	65.3	19.5
June	25.8	58.0	24.0

Fig. 1. Measured and predicted plant height versus nitrogen application rates

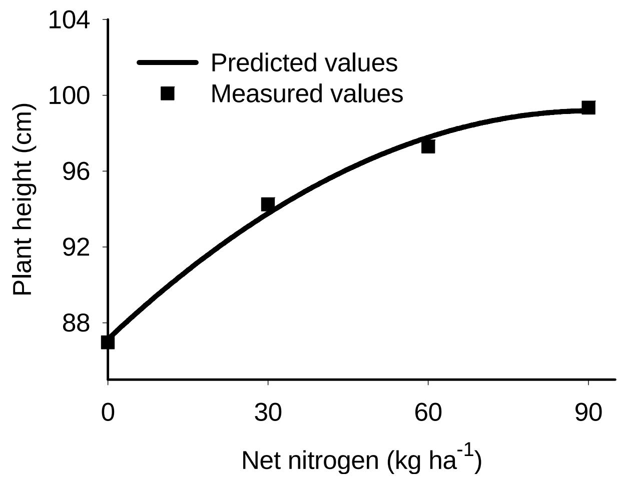
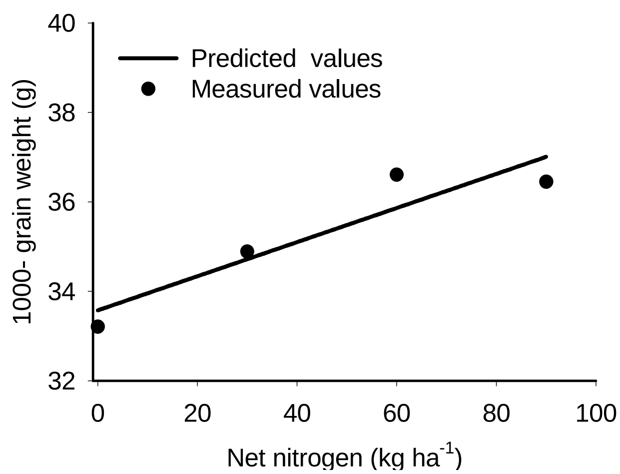


Fig. 2. Measured and predicted TGW values versus net nitrogen



Grain yield. Nitrogen application significantly ($P \leq 0.01$) enhanced grain yield. Increasing N from 60 to 90 kg ha^{-1} failed to increase yield further.

1000-grain weight. Effect of nitrogen application on TGW was significant ($P \leq 0.01$). TGW averaged as 33.2, 34.9 g for N_0 and N_1, respectively. TGW from N_2 and N_3 was 36.5 g and were statistically identical. A linear model was worked

Fig. 3. Measured and predicted spikes per m^2 values versus net nitrogen

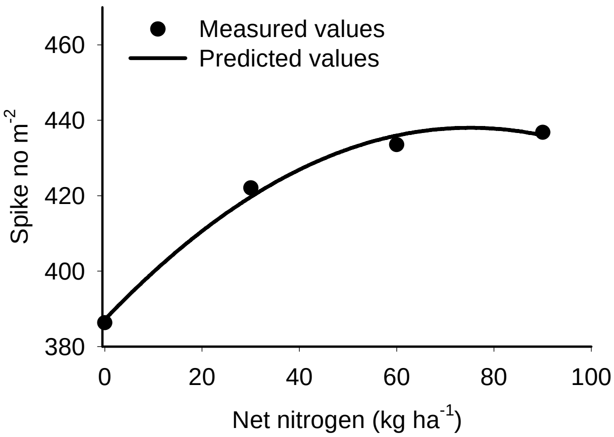


Fig. 4. Measured and predicted grains per spike versus net nitrogen application

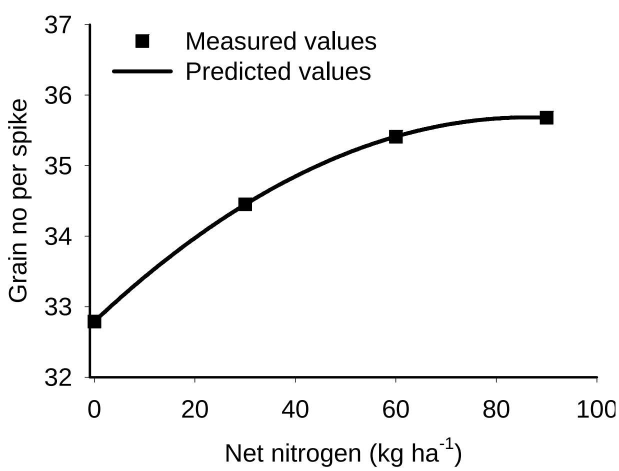
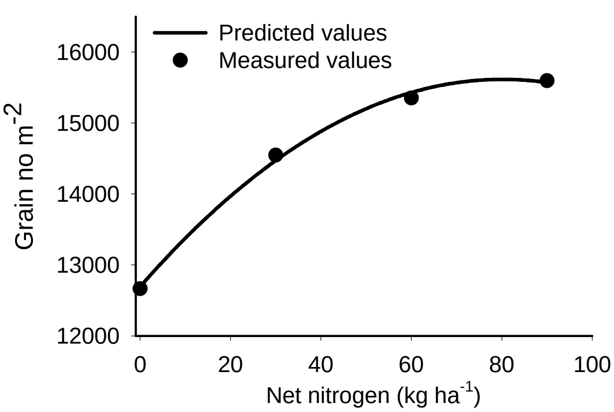


Fig. 5. Measured and predicted grains no per m^2 versus nitrogen application



out as follows to describe the relationship between 1000-grain weight and applied nitrogen (Moghaddam, 1999):

$$TGW= 33.57+ 0.038\ N \qquad r =0.93 \qquad (2)$$

In which TGW and N are 1000-grain weight and applied net nitrogen (kg ha^{-1}). The measured and predicted TGW values against net nitrogen are displayed by Fig. 2.

Spikes per unit area. Nitrogen application affected spikes per m^2 ($P \leq 0.01$). This finding is consistence with those reported by Camberato and Bock (1990), Yazdi Samadi and Abdmishani (1991), Zebart and Sheard (1992), Danaei (1993), Ayoub *et al.* (1994) and Khaliq *et al.* (1999). SN1 averaged as 386, 422, 434 and 437 for levels of N_0, N_1, N_2 and N_3, respectively. The achieved SN1 from N_2 and N_3 were nearly identical. Increasing SN1 with increase in N application originated from increase in tillers per unit area (Ayoub *et al.*, 1994).

The relationship between spikes m^{-2} and applied nitrogen was described by a quadratic model as follows:

$$SN1= 387.111+ 1.356\ N-0.009\ N^2 \qquad R^2=0.99 \qquad (3)$$

where SN1 and N are spikes per m^2 and applied net nitrogen (kg ha^{-1}), measured and predicted values of SN1 versus net nitrogen was shown in Fig. 3.

Spikelets per spike. Nitrogen application increased spikelets per spike. SNS averaged as 13.0 and 13.5 for nitrogen levels of N_0 and N_1. The SNS (13.7) produced by applying 60 and 90 kg N ha^{-1} were statistically similar. These results imply that SNS is directly related to the applied nitrogen. This is accordance with those findings of Camberato and Bock (1990), Rash and Rao (1990), Rahnoma (1993) and Swarup and Sharma (1993).

Grains per fertile spikelet. Nitrogen application positively increased grains per fertile spikelet ($P \leq 0.05$). Applying 60 and 90 kg N ha^{-1} produced similar GNST equiling 2.6, while 30 kg N ha^{-1} and no-nitrogen produced identical GNST equaling 2.5. Increasing from 60 to 90 kg N ha^{-1} caused no increase in GNST.

Grains per spike. N application effects on grains per spike were also statistically significant ($P \leq 0.001$). GNS averaged as 32.8, 34.5, 35.5 and 35.7 for N_0, N_1, N_2 and N_3, respectively. Increasing GNS with increase in utilization of nitrogen was also reported by Danaei (1993), Fischer *et al.* (1993), Ayoub *et al.* (1994), Mossedaq and Smith (1994), Shah *et al.* (1994) and Khaliq *et al.* (1999). These results may be due to increasing spikelets per spike and grains per spikelet. The relationship between grains per spike and applied nitrogen described by the quadratic model reads as:

$$GNS= 32.790+ 0.067\ N-0.0004\ N^2 \qquad R =0.99 \qquad (4)$$

Where GNS and N are grain no per spike and applied net nitrogen (kg ha^{-1}). Fig. 4 shows measured and predicted values of GNS variations against net nitrogen.

Grains per unit area. The N application effects on grains per unit area (GNSM) were statistically significant ($P \leq 0.001$). Grains no is related to fertile spikelets per m^2 and spikelets per spike. The GNSM averaged as 12666, 14547, 15353 and 15597 with nitrogen levels of N_0, N_1, N_2 and N_3, respectively.

The highest GNSM produced by 90 kg N ha^{-1} was 1.2 times of the lowest that was recorded in plots with no-nitrogen fertilization. Increasing GNSM with increase in nitrogen application is in accordance with Ayoub *et al.* (1994), Malakouti and Nafisi (1994), Mossedaq and Smith (1994) and Shah *et al.* (1994). Grains per m^2 were related to the applied nitrogen by a quadratic model as:

$$GNSM = 12691.4 + 72.934\,N - 0.455N^2 \quad R^2 = 0.99 \quad (5)$$

Where GNST and N are grains per m^2 and applied net nitrogen (kg ha^{-1}). Measured and predicted values of GNSM against net nitrogen were displayed in Fig. 5.

CONCLUSION

Nitrogen application had positive influence on all the yield components. However, the response with nitrogen application of 60 and 90 kg ha^{-1} was statistically similar. Therefore, to achieve the optimum values of yield components, application of nitrogen with rate of 60 kg ha^{-1} is recommended for Gonbad and similar climate and cultivation conditions. Developed models may be applied to predict TGW, PLH, SN1, GNS and GNSM as a function of nitrogen application for rainfed condition and need to be confirmed further for wider viability.

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