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Response of Bread Wheat to Nitrogen Application in Calcareous Soils of Western Iran

[1]Rahim Naseri, [2]Amir Mirzaei, [3]Reza Soleimani and [1]Ehsan Nazarbeygi

[1]Young Researcher Club, Islamic Azad University of Ilam, Iran
[2]Phd. Student of Islamic Azad University, Karaj, Iran
[3]Scientific Board Member of Agriculture and Natural Resources Research Center, Ilam, Iran

Abstract: This research was done for determining the effect of application nitrogen rates on yield and yield components of three wheat cultivars in calcareous soils of western Iran. Experiment was conducted as split plot and randomized complete block design (RCBD) with three replications in 2007-2008. The main plots were three cultivars (Chamran, Verinak and Dez) and subplots were nitrogen rates (0, 80, 160 and 240 kg/ha). The results showed that yield, yield components and associated traits had significantly effect by treatments. The highest and lowest grain yield obtained by Chamran and Dez cultivars, respectively. The results showed that effects of nitrogen rates on yield and yield components were significant. Grain yield, number of spikes/m^2, number of grains per spike, harvest index and protein content increased as polynomial second order by increasing nitrogen rates. The highest grain yield and biologic yield were obtained in 160 and 240 kg/ha with 5100 and 14360 kg/ha, respectively. Decrease of grain yield compared to biological yield in treatment of application of 240 kg/ha was due to decrease of number of spikes/m^2 and number of grains/spike.

Key words: Wheat · Nitrogen · Grain yield and yield components · Calcareous soils

INTRODUCTION

Wheat produce more than 50 percent of requirements protein and calorie for human nutrition in Iran. Management of nitrogen fertilizing is important to increasing wheat production. So, among chemical fertilizer a high correlation reported between nitrogen and yield. Increasing nitrogen application induced increasing leaf area, tiller formation and leaf area index. This resulted in producing more dry matter and grain yield [1]. Rasmussen *et al.,* (1997) indicated that they observed a significant difference in number of spikes/m^2 as affected by nitrogen application [2]. They also suggested that number of grains/spike increased due to increasing nitrogen. Frederick and Camberato (1995) suggested that only in low soil nitrogen condition, yield increase using nitrogen [3]. Khaliq *et al*., (1999) indicated that grain yield, number of spikes/m^2, number of grains/spike and plant height increased with increasing nitrogen rates from 0 to 175 kg/ha [4]. Pilbeam *et al.,* (1997) reported that grain yield increased 890 kg/ha due to increasing nitrogen from 30 to 80 kg/ha [5]. Bole and Dubetz (1986) indicated that more 30kg/ha nitrogen must use per 1000kg yield increasing, but using nitrogen more than 100 kg/ha induced reducing grain yield response per 1 kg added nitrogen [6]. Maximum grain yield using 150 kg nitrogen ha and using higher rates caused to decreasing grain yield. Ali *et al.,* (2003) suggested that productive tillers m^{-2}, 1000-grain weight and grain yield of wheat increased with the application of 150 kg/ha N [7]. Jokela and Randall, (1989) also reported that increasing nitrogen rates from zero to 150 kg/ha caused to increasing grain yield, but increasing it to 225 kg/ha didn't caused to increasing grain yield [8]. Using fertilizer is profitable until yield increasing rate supply fertilizer cost, using much nitrogen can resulted in problems such as stem lodging, ground waters polluting, much cost, physical soil demolishing and environment pollution [9-11]. Due attention to determining nitrogen rate is necessary to determining plant respond to fertilizer. In these experiment, it is necessary to regional soil, climate conditions and cultivars changes are important, thus the study conducted to investigating effects of different nitrogen rates on grain yield and yield components wheat cultivar in western Iran.

Corresponding Author: Naseri Rahim, Former M.Sc. Student College of Agric., The University of Ilam, Iran.
And Islamic Azad University Young Researcher Club, Ilam, Iran. E-mail: rah_naseri@yahoo.com.

Table 1: Physical and chemical soil characteristic of the experimental site

	P	K	TNV	Total N	O.C	E.C	pH
Texture Soil	---------- mg kg^{-1} ----------			----%----	---------- dsm^{-1} ----------		
Silty loam	4.2	290	43	0.09	1.01	0.62	7.2

MATERIALS AND METHODS

This study conducted in 5 km north of Mehran, in weatern Iran with 33™ Northen and 46™ latitude and 155 m height from sea. Results of soil test showed in Table 1.

This experiment was as split plot randomized complete block design with three replications in 2007-2008 in Mehran in western Iran. The main plots were three cultivars (Chamran,Verinak and Dez) and subplots were nitrogen rates (0, 80, 160 and 240 kg/ha). Preparation on operation included plough, disk harrow and leveler. Planting conducted handy in 15 Aban. In this experiment cultivars planted as 450 plant/m2. Any row was 4 m and any plot included 8 lines. Main plots had 1 m interval and sub plots interval was 50 cm and replications intervals was 2m. Wheat seed soaked with vitavax before planting. 120 kg/ha phosphate used based on soil test potassium wasn't necessary in this study. Irrigation conducted as flooding. All nitrogen rates used in three stage including planting, tillering and stem stages. 10 plants height measured randomly in harvest stage. Harvesting performed to measuring grain yield after omitting side lines and omitting 50 cm from end and beginning of lines. Spike/m^2 counted in 1m^2. Grains per spike determined randomly for 10 spikes. 1000-grain weight also determined by weighting of 1000 seeds. The protein content was measured by micro Kjeldahl digestion using automated colorimetric analysis. Statically analysis conducted using SAS and MSTAT-c software and graphs drawn using Excel. Mean comparison was conducted using the Duncan's Multiple Range Test (DMRT).

RESULTS AND DISCUSSION

Effect of cultivars was significant on grain yield, number spikes/m^2, grain number per spike, 1000-grain weight, harvest index and biological yield, bud they hadn't effect on plant height and protein content. Different nitrogen rates had significant effect on all traits (Table 2).

Mean grain yield comparison indicated that the highest yield belonged to Chamran cultivar, 4976.5 kg. ha. Different nitrogen rates yielded different grain yield. Increasing grain yield was due to increasing yield components. The highest and lowest grain yield in 0 and 160 kg/ha rates yielded 2963.8 and 5100 kg/ha, respectively, that different is 72.2%. 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 [12]. In this experiment, grain yield changes followed by Mitscherlich law. Segregation mean squares to linear, quadratic and cubic components showed that increasing nitrogen rates caused to linear increasing grain yield but increasing rate reduce gradually using higher nitrogen rates and followed quadratic model (Table 3 and Figure 1). These results are in agreement with findings of Alcoz *et al.,* 1993 and Frederick and Camberato, 1990 [13]. Also it indicated that grain yield respond is linearly by increasing nitrogen rate from zero to 150 kg/ha. if nitrogen rate increasing to 200 kg/ha, yield wouldn't change [14]. Lopez Billido and Bellido, (2001) found by studying different nitrogen rates (0, 50, 100 and 150 kg/ha) that wheat grain yield

Table 2: Analysis of variance for yield and yield components in application nitrogen rates

		MS							
S.O.V.	df	Grain yield	Spike/m^2	Grain per Spike	1000 grain weight	Harvest index	Biological yield	Plant height	Protein content
Replication	2	21000.8	297.1	9.2	8.08	9.5	12775.5	80.1	2.30
Cultivars	2	3219733.03**	708.6**	111.5**	45.5*	137.02*	155169.7**	16.3ns	0.004ns
Error 1	4	1719640.2	14.9	3.5	3.2	11.02	30993.08	8.56	0.43
Nitrogen	3	10897005.9**	15687**	379.9**	446.7**	362.4**	10369160.6**	2952.7**	22.8**
Interaction	6	224799.6**	60.69**	6.6**	3.28*	5.7ns	79862.1*	12.5ns	0.20ns
Error 2	18	37010.9	11.6	1.4	1.09	6.7	19615.4	8.37	0.38
CV%		10.5	8.5	7.4	7.1	8.6	13.5	9.8	6.2

* and**: Significant at 5% and 1% levels, respectively

ns: Non -significant

Table 3: Segregation mean squares traits in application nitrogen rates via orthogonal polynomial

		MS							
S.O.V.	df	Grain yield	Spike/m^2	grain per Spike	1000 grain weight	Harvest index	Biological yield	Plant height	Protein content
Nitrogen	3	10897005.9**	15687**	379.9**	446.7**	362.4**	10369160.6**	2952.7**	22.8**
Linear	1	16623330**	22781.2**	638.4**	1490.6**	736.08**	736.08**	8848.02**	51.6**
Quadratic	1	7165436.6**	20211.3**	306.2**	5.4ns	336.1**	336.1**	7.1ns	15.86**
Cubic	1	36210^{ns}	700.1^{ns}	2.9^{ns}	1.4^{ns}	15.02^{ns}	15.02^{ns}	3.2^{ns}	1.6^{ns}

* and**: Significant at 5% and 1% levels, respectively

ns: Non -significant

Table 4: Mean comparisons of cultivars and nitrogen rates on agronomic traits

Treatment	Grain yield (kg/ha)	Spike/m^2	Grain per Spike	1000 grain weight (g)	Harvest index (%)	Biological yield (kg/ha)	Plant Height (cm)	Protein content (%)
Cultivars								
Chamran	4979.6a	368.08a	37.9a	40a	33.7a	13630a	106.3a	111.8a
Verinak	4249.6b	359.5b	35.2b	37.2b	30b	13490ab	105a	111.8a
Dez	3673.7b	352.7c	31c	36.2b	27b	134140b	103.9a	111.8a
Nitrogen (kg/ha)								
0	2963.8c	299.8d	25.8d	29.2d	21.4c	12002d	83.4c	9.6d
80	4407.4b	375.7b	35.5b	35.7c	30.4b	13480.8c	98.8c	11.6c
160	5100.5a	395.8a	41.1a	40b	36.2a	14190.4b	112.1b	13.3a
240	4758.8ab	368.8c	37.4b	45.7a	33.3b	14360a	125.7c	12.6b

Means, in each column, followed by similar letter are not significantly different at the 5% probability level- using Duncans Multiple Range Test

Table 5: Mean comparison of interaction effects cultivars × nitrogen rates on agronomic traits

Treatment	Grain yield (kg/ha)	Spike/m^2	Grain per Spike	1000 grain weight (g)	Harvest index (%)	Biological yield (kg/ha)	Plant Height (cm)	Protein content (%)
C1N1	2903.3f	314g	27.3g	29.6e	23.6de	12030.3f	82.3e	9.4d
C1N2	4713.3cd	385c	38c	38.6c	34.3b	13450e	99.3d	11.5c
C1N3	5930a	400a	45.6a	43.3b	40.6a	14370b	114c	13.5a
C2N4	5366.3b	373.3d	40.6b	48.3a	36.3ab	14670a	129.2a	12.7ab
C2N1	2561.6g	295.3h	25.6gh	29.3e	21e	12020f	83.3e	9.5d
C2N2	4626.6cd	375.6d	36d	35d	29c	13400e	100.6d	11.7bc
C2N3	4950.3c	395ab	41.6b	40c	36.3ab	14200.3bcd	111.6c	13.3a
C2N4	4860c	372de	37.6cd	44.6b	34b	143204bc	126.3b	12.5abc
C3N1	2421g	290.3h	24.6h	28.6e	19.6e	11960.3f	84.6e	9.9d
C3N2	3881.6e	366.6ef	32.6e	33.6d	28cd	13580.6e	96.6d	11.7bc
C3N3	4420d	392.6b	36d	38.3c	31.6bc	14000d	110.6c	12.9a
C3N4	4050.3e	361.3f	34e	43.3b	28.6c	14090cd	123.6b	12.5abc

Means, in each column, followed by similar letter are not significantly different at the 5% probability level- using Duncans Multiple Range Test

C_1,C_2 and C_3= Chamran, Verinak and Dez cultivar respectively

N_1, N_2, N_3 and N_4= 0, 80, 160 and 240 kg/ha nitrogen fertilizer, respectively

hadn't any respond to increasing nitrogen more than 100 kg/ha [15]. Interaction effects of cultivar and nitrogen on grain yield were significant. It is mean that cultivars reaction to changing nitrogen rates would change. In this study, the highest grain yield yielded using 160 kg/ha nitrogen in chamran cultivar, average 5930 kg/ha and the lowest grain yield yielded using no-nitrogen fertilizer in Dez cultivar, average 2421 kg/ha (Table 5).

Cultivars had significantly different spike/m^2 (Table 4). In this study the highest spike/m^2 yielded iv Chamran cultivar. Increasing nitrogen rate caused to increasing spike/m^2. The highest an lowest fertilizer rates had significantly different due to increasing fertile tillering number using high fertilizer rates. Increasing nitrogen application to 160 kg/ha caused to increasing spike number (Table 4). Simons (1982) reported that

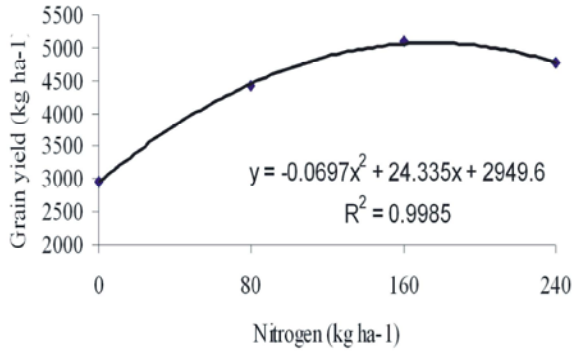

Fig. 1: Effect of nitrogen rates on grain yield

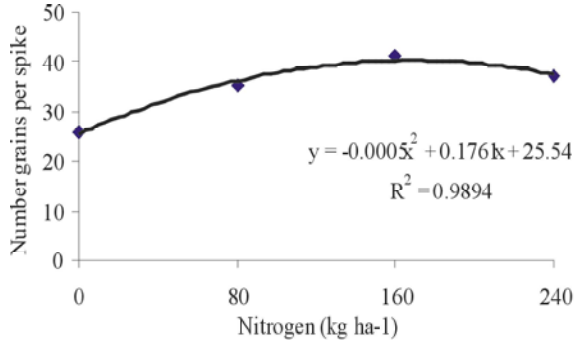

Fig. 3: Effect of nitrogen rates on number grains per spike

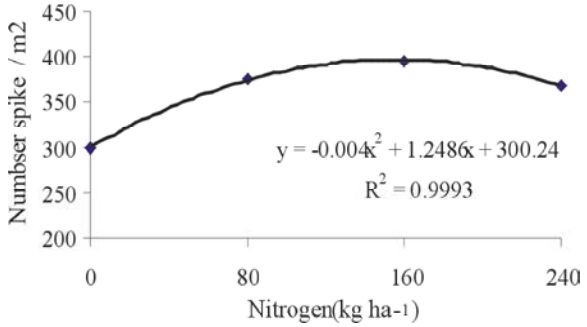

Fig. 2: Effect of nitrogen rates on number spike/m^2

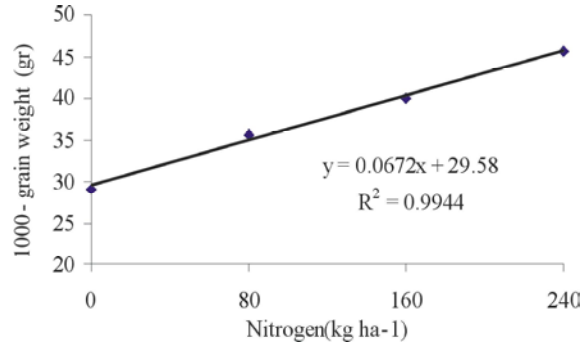

Fig. 4: Effect of nitrogen rates on 1000-grain weight

formed tillers duration would become longer due to increasing nitrogen rate [16]. Camberato and Bock, (1990) indicated that increasing nitrogen rate resulted in increasing yield via increasing spike/m^2 [17]. Ayoub *et al.,* (1994) suggested that proportional and true using nitrogen caused to increasing grain yield of wheat by increasing spike/m2 [18]. Dawari and Luthara, (1991) showed that there is a direct and positive relation between increasing fertile of tillers number and grain yield because at this case, leaf area and transforming and storing rate of carbohydrate to grain would increase [19]. But this study using 240 kg/ha caused to decreasing spike/m^2 Being significant quadratic partial of spike/m^2 trait can attributed to grain yield change as quadratic (Figure 2). Interaction effects of cultivars and nitrogen was significant on spike/m^2. In this experiment highest spike/m^2 yielded using 160 kg/ha nitrogen in Chamrn cultivar, by mean of 400 spike/m^2 and lowest spike/m^2 yielded using nitrogen fertilizer in Dez cultivar by mean of 290 spike/m^2 (Table 5).

As mean comparison table showed, Chamran and Dez cultivars yielded highest and lowest grains number per spike, respectively (Table 4). Experiment results showed that grains number per spike. Increased linearly due to increasing nitrogen. High and low rates did significant different. Reducing nitrogen has negative effect on grains number per spike by a affecting providing decreasing matter to grain and as result reducing leaf area, leaf duration and photosynthesis and finally penetration light. Fertilizer rates more than 160 kg/ha decreased competition and as result florets and flowers abortion and finally caused to increasing grains per spike due to supplying more suitable nutritious conditions, for plant during florets distinction and flowers growth stage. The highest and lowest grains per spike yielded using 160 kg/ha and non using fertilizer, average 39 and 25.8 grains, respectively (Table 4). Maitlo *et al*., (2006) indicated that the integrated using of 75 kg/ha N and 2-2.5% foliar urea solution improved growth, yield, nutrient uptake and quality of wheat [20]. Demotes-Mainarda and Jeuffroy, (2004) indicated that deficit nitrogen during spike growth or after flowering caused to reducing dry weight of spike and also grains per spike [21]. Similar to spikes/m2 trait, grains per spike also increased as linear model, but using more nitrogen than 240 kg/ha, grains per spike decreased and followed quadratic (Table 3 and Figure3). Fischer, (1993) reported that grains per spike increased due to increasing nitrogen rate [22]. Interaction effects of cultivars and nitrogen was significant on grains per spike (Table 2).

In this study highest grains per spike yielded using 160 kg/ha nitrogen in Chamran cultivar averagely 45.5 grains and lowest yielded using no nitrogen fertilizer in Dez cultivar, average 24.6 grains (Table 4).

Chamran cultivar had highest 1000-grain weight by mean of 38.2 g. 1000-grain-weight increased due to increasing nitrogen rate, lowest 1000-grain weight (28.1 g) yielded using no fertilizer which had significant different with other rates (Table 4). Using 240 kg/ha nitrogen yielded highest 1000-grain weight. High 1000-grain weight using nitrogen rates more than 240 kg/ha is due to supplying more nutrients because of low spikes/m2 and grains per spike that in this state grains have more access to photosynthetic matters and results in increasing 1000-grain weight. Martin and Slafer, (2006) showed that mean grains weight of wheat decreased due to increasing grains number or due to competition or increasing lowest weight grains potential [23]. Interaction effects of cultivar and nitrogen on 1000-grain weight were significant (Table 2). In this study the highest 1000-grain weight yielded using 240 kg/ha nitrogen in Chamran cultivar (48.3 g) and lowest 1000-grain weight yielded using no fertilizer in Dez cultivar (24.6).

Harvest index indicated how photosynthetic matters distributed in economical sinks and other sinks of plant. Means comparison table showed that Chamran cultivar had highest harvest index (34.1 percent) followed by Verinak cultivar, mean 30 percent (Table 4). Study results indicated that harvest index influence by nitrogen as increasing nitrogen rate caused to increasing harvest index. Lowest harvest index yielded using no nitrogen fertilizer which had significant different. Lowest and highest harvest index different was 69.1% which was statically significant (Table 4). As there is competition between reproductive and vegetative organs to uptake photosynthetic matters it can be expected that the competition increased due to increasing nitrogen and because reproductive sinks form later than vegetative sinks, harm effects resulted from increasing fertilizer and competition befall to reproductive sinks and resulted in aborting many reproductive organs. In addition increasing nitrogen lead to sever stem lodging and because lodging cause to deranging uptake and transforming deserved matters and nutrients finally it caused to transforming stated nutrients in stem stages rates more than 240 kg/ha.

Cultivars had significant different biological yield. Chamran cultivar highest biological, mean 13630 kg/ha (Table 4). Lioyd *et al.,* (1997) reported that significant different observed between cultivars [24]. Different nitrogen rates had significant different biological yield. Increasing nitrogen caused to linear increasing biological yield. Non-using nitrogen and using 240 kg/ha yielded lowest (12002 kg/ha) and highest (14360 kg/ha) biological yield, respectively. Biological yield different was 19.6%. Effect of nitrogen application on biological yield is resulted from that dry weight of leaf, plant weight and vegetable growth of plant increased due to increasing nitrogen rate and this cause to increasing total biological yield. These results are an agreement with findings of Lasztity, (1987) [25]. Nunes *et al*., (1996) indicated that biological yield and grain yield increased with increasing N rate [26]. Interaction effects of cultivar and nitrogen was significant effect on biological yield (Table 2). In this study highest biological yield produced using 240 kg/ha. Chamran cultivar (14670 kg/ha) and lowest biological yield produced using no nitrogen fertilizer in Dez cultivar (11960.3 kg/ha) (Table 5). These results agree with those reported by Powal (1998), Shaikh *et al.,* (1994) and Majid *et al.,* (1986) [27-29].

Cultivars had significant different plant height. Vilson *et al.,* (1996) pointed to no significant reaction of plant height to different nitrogen rates [30]. Mean comparison of different nitrogen rates indicating linear increasing plant height using higher nitrogen rates. This linear partial is linear regression of plant height using fertilizer rates and being significant it showed that increasing height has linear relation significantly with increasing fertilizer rate. Moghaddam *et al.,* (1997) suggest that using nitrogen fertilizer cause to increasing branches and leave and internodes long [31].

There wasn't significant in protein content between cultivars (Table 4). Protein content increased linearly due to increasing nitrogen rate. No using and using 160 kg/ha nitrogen yielded lowest and highest protein content, respectively, this indicating 38.5% different (Table 4). Nitrogen fertilizers increase the arrived nitrogen from vegetative parts to grain in compared with carbohydrate and cased to increasing nitrogen concentration and its protein content. It also showed that increasing nitrogen from 160 kg/ha to 240 kg/ha resulted in reducing protein content. In higher fertilizer rates, most part of nitrogen is nitrate ions instead of amino acids or proteins. Obtained results showed that increasing nitrogen has positive effects on yield and yield components, in spite of all that, using excess nitrogen didn't increase grain yield but caused to reducing it and even it can resulted in increasing production cost, water sources pollution and stem lodging [32, 33].

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