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GROWTH AND YIELD OF WINTER WHEAT (TRITICUM AESTIVUM) AS AFFECTED BY NITROGEN AND IRRIGATION

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ABSTRACT

Wheat is one of the important grain crops produced worldwide. Low soil nitrogen (N) availability and water deficit are often the major factor limiting of crops growth. Therefore, in order to evaluation impact of nitrogen fertilization and irrigation regimes on growth of winter wheat plants, a field experiment in split split plot based on Randomized Complete Block Design with three replications was conducted at 2008-2010 in the research field of Karaj, Iran. Treatment included: two wheat cultivars (Gascogne and MV-17), three levels of nitrogen (0, 75 and 150kg N ha^{-1}), and three levels of withholding irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage). Based on results, the highest number of plant per meter square observed in tillering stage and Approaching to maturity stage number of plant was reduced. Application of 75 and 150 kgNha^{-1} increase number of plant per meter square at tillering, heading, and maturity stages compared with control treatment. In contrast, withholding irrigation was caused that plant number reduced at heading and maturity stages. Withholding irrigation at anthesis stages (I_2) had severely effects on number of plant in heading and maturity stages.

Keywords: **Drought, Grain Filling Period, Maturity Stage, Population, Tillering**

INTRODUCTION

Higher-yielding varieties, higher water-use efficient cultivars, better and improved agronomic technologies and more governmental support are needed to produce enough wheat for the projected 120 million people in Iran in 2025. The gap between the attained and attainable yield needs to be bridged over time through better dissemination of production technologies and special planning and supportive action by the Government. Drought occurs in almost all climatic regions, and is a normal, temporary, and recurring feature of climate. Also important to determine the severity of drought on a specific region, is to examine the demand placed on the water supply of that region by human activities and vegetation [1 and 2]. Excluding available soil water, N is the next most limiting factor in local wheat production as in other wheat production areas worldwide [3 and 4]. Nitrogen (N) is currently the most widely used fertilizer nutrient and the demand for it is likely to grow in the near future [5]. The available soil water and tillage methods also affect the quantity of residual soil mineral N available. In the other hand, the purpose of irrigation management and fertilizer application is supply of plant needs in the best time and the most sensitive growth stage. Several factors have been identified that affect the response of wheat to N [6]. Tiller production can be important in determining eventual grain yield, and is closely associated with rate of leaf emergence [7]. Therefore, the main purpose of this work is assessment the effect of nitrogen fertilization and irrigation regimes on growth and number of plant per unit area at different growth stages of winter wheat at Karaj conditions.

MATERIALS AND METHODS

This study was conducted at 2008-2010 in the research field of Karaj agricultural administration province, Iran ($35^0 48^{'}$ N, 51.00^0 E; 1360 m elevation). Before conduct of experiment, composite soil samples from experimental sites were collected from 0-30 cm depth. Soil samples were analyzed for physico-chemical properties. The results of soil analysis were shown in Table (1). There were 18 treatments in three replications. Treatment included: cultivars (Gascogne and MV-17), three levels of nitrogen (0, 75 and 150 kg N ha^{-1}), and three levels of withholding irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage). The field experiment was laid out in split split plot based on Randomized Complete Block Design with three replications. Cultivars placed in Main plot, nitrogen levels in sub plot and irrigation regimes in sub subplot. Number of wheat plants per m^2 in each plot area was recorded at different growth stages such as the tillering stage, heading and maturity stages. Then total losses of plant (%) were measured.

RESULTS AND DISCUSSION

The accurate simulation of leaf area in wheat models is important because leaf area intercepts light and stores nitrogen, and the arrangement of leaves influences the transmission of foliar diseases and inter-species competition [8]. According to the results, the highest number of plant per meter square observed in tillering stage and Approaching to maturity stage number of plant was reduced. In this case, there was a positive interaction between fertilizer N and applied irrigation or available soil water. At maturity stage, number of plant in Gascogne and MV-17 cultivars was recorded 729.6 and 622.6 (plant m^{-2}), respectively. Based on Table (2), using nitrogen in three years resulted in increase in number of plant at tillering, heading and maturity stages. Results of three experimental years were shown that, application of 75 and 150 kg N ha^{-1} increase number of plant per meter square 24% and 52.8% at tillering, 34.6% and 65.4% at heading, 64.3% and 56.3% at maturity stages compared with 0 kg N ha^{-1}. [9] showed that crop demand for N is intimately linked with the balance between N concentration in green area and total green area. Response of Gascogne cultivar to nitrogen application is better than MV-17 cultivar in all years especially at maturity stage (Table 3). Withholding irrigation was caused that plant number reduced from 823.5 to 731.0 (-11. 2%) at heading stage and from 799.3 to 537.0 (-32.8%) at maturity stage (Table 2). Therefore, omit irrigation resulted reduce in number of plant at maturity stage for three years, severely (Fig 1). Reduce the number of plant in MV-17 was higher than Gascogne cultivar and cultivars response to withholding irrigation was very different. Total losses plant at maturity stage increase from 6.1% in I_1 treatment (regular irrigation) to 39.4% in I_3 (withholding irrigation at seed filling period). While, the results were shown that response of total losses plant at maturity stage to nitrogen application is differed. In all of experimental years, maximum plant losses, were observed with 75 and 150kg N ha^{-1} application but had no effect on losses plant percent. These results are in conformity with those of [10] and [11]. Gascogne cultivar had minimum losses plant at maturity stage compared MV-17 cultivar (20.0% in Gascogne compared 22.0% in MV-17) (Table 3). Withholding irrigation at anthesis stages had severely effects on number of plant in heading and maturity stages and reduced its (Number of plant reduced to 749.7 and 692.0 respectively). Similar results have also been reported by [12]. Based on previous study, anthesis is important in the life of a wheat canopy because at that stage all new green area has been produced [8]. Cultivars had dissimilar response to omit irrigation and number of plant in heading and maturity stages, were affected by cultivar and irrigation regimes interaction (Table 4). The results obtained of this experiment shown that higher nitrogen application and drought stress resulted in lower grain weight in wheat. Moreover, data analyses for the 3-year experiment showed that nitrogen fertilization up to 75 kg N ha^{-1} had no significantly effects on 1000-grain weight, but with 150 kg N ha^{-1} application compared 0 kg N ha^{-1} (check treatment), 1000-grain weight increased (Fig 2). Similar results were recorded by [13] and [14]. Drastic decrease in 1000-grain weight was recorded as the drought stress increased but highest reductions were found in I_3 (withholding irrigation at seed filling period) followed by I_2 (anthesis drought). Also, Lowest of 1000 grain weight was recorded in V_1I_3 and V_2I_3 treatments (40.45 and 40.45 gram respectively). The highest 1000-grain weight was recorded in MV-17 at control (44.5 gr) as well as at withholding irrigation at anthesis stage (44.0). [15] and [16] emphasized that 1000-grain weight of wheat was reduced mainly due to increasing water stress. Also, nitrogen fertilization had no significantly effects on 1000-grain weight in all two cultivars (Table 3). The highest wheat yield was obtained when that 150Nkgha^{-1} was applied compared with control treatment (8394 kgha^{-1} compared with 5385 kgha^{-1}). Withholding irrigation at anthesis caused that economic yield was declined from 8392.0 kgha^{-1} to 7173.5 kgha^{-1} compared with check treatment (15.6%). Gascogne yield due to water stress reduced and from 8426 kg ha^{-1} reach to 6949 kg ha^{-1} in water stress at anthesis stage and 4909.5 kg ha^{-1} with withholding irrigation at seed filling period. Response of MV-17 cultivar was similar to Gascogne. The grain yield of MV-17 from 8358 kg ha^{-1} at regular irrigation declined and reaches to 7398.5 kg ha^{-1} in water stress at anthesis stage and 5065 kg ha^{-1} with withholding irrigation at seed filling period (Table 3). Drought at critical stages of anthesis and grain filling has a detrimental effect on grain filling, grain yield and quality traits [17 and 18]. Interaction effects between irrigation regimes and N rates were shown that under well-watered and withholding irrigation at anthesis stage conditions, grain yield were increased in the high-N treatment (150 kg N ha^{-1}) as compared to the low-N treatment (0 and 75 kg N ha^{-1}) (Table 2). The results of our study showed that the highest grain yield was obtained with MV-17 cultivar in all of growing seasons (6940.4 kg ha^{-1}) (Table 2).

CONCLUSION

Nitrogen applications for adequate N availability early in crop development promotes tillering, leaf growth, and potential grain number. Usually, N applications at planting, and early to late tillering increases tiller count and ear size (during the spikelet formation phase), and thereby yield potential. The results of this experiment were shown that, application of 75 and 150 kgNha^{-1} increase number of plant per meter square 24% and 52.8% at tillering, 34.6% and 65.4% at heading, 64.3% and 56.3% at maturity stages compared with control treatment. Also, lower amount of N fertilizer, decreased tiller number per meter square due to lower tiller production and higher tiller death. In this experiment, effects of nitrogen rates and irrigation regimes showed that grain yield increased with the gain of N rate (by 25.7% at N75 and by 55.9% at N150 compared with N0) and decreased with the increase of water stress during growth stages (by 14.5% at withholding irrigation at anthesis stage and by 40.6% at withholding irrigation at seed filling period compared with regular irrigation).

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Table1: Soil characteristics of experimental location

Soil properties	2008	2009	2010
Sand (%)	15	16	13
Clay (%)	40	43	41
Silt (%)	45	41	46
Soil texture	Silty clay	Silty clay	Silty clay
Organic matter (%)	2.0	2.2	2.1
pH	7.1	7.0	7.1
Electrical conductivity (dsm^{-1})	0.63	0.67	0.52
N (%)	0.13	0.13	0.11
P (ppm)	8.2	8.6	8.9
K (ppm)	359	382	354
Zn ($mg.kg^{-1}$)	0.55	0.63	0.51
Fe ($mg.kg^{-1}$)	2.8	2.5	3.2
Mn ($mg.kg^{-1}$)	2.5	2.5	2.7

Table 2: The effect of year and other treatment on evaluated traits (average three years 2008-2010)

Traits / Treatment		seed sowing density (m2)	NPGS: Number Of plant in germination stage	NPTS: Number Of plant in tillering stage	NPHS: Number Of plant in heading stage	NPMS: Number Of plant in maturity stage	NLP: Number losses Of plant	TLP: Total losses Of plant (%)	TGW: 1000-grain weight (gr)	EY: Economic yield ($kgha^{-1}$)
Year		500	479.7	871.8	770.6	676.1	195.7	22.4	42.0	6850.8
V_1		500	480.5	915.1	480.5	729.6	185.5	20.0	41.8	6761.3
V_2		500	478.8	828.6	478.8	622.6	206.1	22.0	43.0	6940.4
N_0		500	479.2	687.7	589.3	533.5	154.2	21.3	42.4	5385.0
N_{75}		500	480.0	860.4	775.4	769.6	90.8	22.1	42.3	6773.5
N_{150}		500	480.0	1067.5	947.2	825.2	242.2	21.4	42.4	8394.0
I_1		500	481.9	866.2	823.5	799.3	66.9	6.1	43.4	8392.0
I_2		500	477.9	866.2	749.7	692.0	174.2	19.2	43.3	7173.5
I_3		500	479.3	883.3	731.0	537.0	346.2	39.4	40.5	4987.5
N_0	I_1	500	487.0	710.3	668.3	670.0	40.3	2.4	43.8	7100.0
	I_2	500	469.3	673.3	576.3	531.3	142	20.9	43.5	5267.0
	I_3	500	481.3	679.8	523.5	399.5	280.3	40.7	40.0	3789.0
N_{75}	I_1	500	479.3	861.4	841.5	824.8	36.6	4.2	43.2	8766.0
	I_2	500	483.0	866.5	728.4	687.0	179.5	20.4	43.2	7093.0
	I_3	500	477.8	853.4	756.3	497.1	356.3	41.6	40.5	4462.0
N_{150}	I_1	500	479.5	1027.0	960.8	903.3	123.7	12.0	43.2	9311.0
	I_2	500	481.5	1059.0	944.5	857.8	201.2	16.3	43.2	9161.0
	I_3	500	479.0	1117.0	936.5	714.6	402.4	35.9	41.0	6711.0
Average			479.7	871.9	737.9	681.7	190.2	21.6	42.4	6851.0
Cv (%)			2.51	4.91	3.34	4.97	6.32	7.52	5.61	3.37

Cultivars (V_1: Gascogne and V_2: MV-17) ; Three levels of nitrogen (N_0:0, N_{75}: 75 and N_{150}: 150 kg N ha^{-1}) ; Three levels of irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage); Cv: Coefficient of variation

Table 3: Evaluated traits affected by cultivars, nitrogen and irrigation interaction (average three years 2008-2010)

Variety	Treatment	Seed Sowing Density (M2)	NPGS: Number Of Plant In Germination Stage	NPTS: Number Of Plant In Tillering Stage	NPHS: Number Of Plant In Heading Stage	NPMS: Number Of Plant In Maturity Stage	NLP: Number Losses Of Plant	TLP: Total Losses Of Plant (%)	TGW: 1000-grain weight (gr)	EY: Economic yield ($kgha^{-1}$)
V_1	N_0	500	485	730.85	621.5	557.15	173.7	23.8	41.8	5223.5
	N_{75}	500	477.65	947.95	848	731	216.95	22.95	41.8	6763
	N_{150}	500	479	1067	969.5	900.75	166.25	14.9	41.8	8297
V_2	N_0	500	473.35	644.65	557.2	510	134.65	18.8	42.95	5546
	N_{75}	500	482.3	772.95	702.8	608.2	164.75	21.15	42.8	6778.5
	N_{150}	500	481	1068.5	925	749.65	318.85	27.9	43.15	8491.5
V_1	I_1	500	480.15	921	868.5	873.9	47.1	4.85	42.35	8426
	I_2	500	483.65	901	806.65	740.65	160.35	18.25	42.65	6949
	I_3	500	477.85	923.45	763.85	574.4	349.05	38.6	40.45	4909.5
V_2	I_1	500	483.65	811.45	778.5	724.85	86.6	7.5	44.5	8358.5
	I_2	500	472.15	831.3	692.8	643.35	187.95	20.2	44	7398.5
	I_3	500	480.85	843.2	713.65	499.7	343.5	40.25	40.45	5065
Average			479.7	871.9	737.9	681.7	190.2	21.6	42.4	6851.0
Cv (%)			2.51	4.91	3.34	4.97	6.32	7.52	5.61	3.37

Cultivars (V_1: Gascogne and V_2: MV-17) ; Three levels of nitrogen (N_0:0, N75: 75 and N_{150}: 150 kg N ha^{-1}) ; Three levels of irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage);Cv: Coefficient of variation

Table 4: Evaluated traits affected by cultivars, nitrogen and irrigation interaction (average three years 2008-2010)

Variety	Fertilizer Nitrogen	Irrigation	Treatment	Seed Sowing Density (M2)	Npgs: Number Of Plant In Germination Stage	Npts: Number Of Plant In Tillering Stage	Nphs: Number Of Plant In Heading Stage	Npms: Number Of Plant In Maturity Stage	Nlp: Number Losses Of Plant	Tlp: Total Losses Of Plant (%)	TGW: 1000-grain weight (gr)	EY: Economic yield ($kgha^{-1}$)
V_1	N_0	I_1	$V_1N_0I_1$	500	485	743	706	712.5	30.5	4.1	42.1	7080
		I_2	$V_1N_0I_2$	500	485	723.5	628	557	166.5	23.1	43	4962
		I_3	$V_1N_0I_3$	500	485	726	530.5	402	324	44.4	40.5	3630
	N_{75}	I_1	$V_1 N_{75} I_1$	500	481.5	960	912.5	902.5	57.5	5.9	42.5	8999
		I_2	$V_1 N_{75} I_2$	500	484.5	963.5	822.5	752.5	211	21.7	42.5	7000
		I_3	$V_1 N_{75}I_3$	500	467	920.3	809	538	382.3	41.3	40.5	4291
	N_{150}	I_1	$V_1 N_{150} I_1$	500	474	1060	987	1007	53	4.6	42.5	9199
		I_2	$V_1 N_{150} I_2$	500	481.5	1016	969.5	912.5	103.5	10.1	42.5	8884
		I_3	$V_1 N_{150} I_3$	500	481.5	1124	952	738.2	385.8	30.1	40.5	6808
V_2	N_0	I_1	$V_2 N_0 I_1$	500	489	677.5	630.5	627.5	50	0.7	45.5	7120
		I_2	$V_2 N_0 I_2$	500	453	623	524.5	505.5	117.5	18.8	44	5571
		I_3	$V_2 N_0 I_3$	500	477.5	633.5	516.5	397	236.5	37	39.5	3989
	N_{75}	I_1	$V_2 N_{75} I_1$	500	477	762.8	770.5	747	15.8	2.4	44	8533
		I_2	V2 $N_{75} I_2$	500	481.5	769.5	634.3	621.5	148	19.2	44	7185
		I_3	$V_2 N_{75}I_3$	500	488.5	786.5	703.5	456.2	330.3	42	40.5	4633
	N_{150}	I_1	$V_2 N_{150} I_1$	500	485	994	934.5	800	194	19.4	44	9423
		I_2	$V_2 N_{150} I_2$	500	481.5	1102	919.5	803	299	22.6	44	9439
		I_3	$V_2 N_{150} I_3$	500	476.5	1110	921.5	646	464	41.7	41.5	6613
Average					479.7	871.9	737.9	681.7	190.2	21.6	42.4	6851.0
Cv (%)					2.51	4.91	3.34	4.97	6.32	7.52	5.61	3.37

Cultivars (V_1: Gascogne and V_2: MV-17)
Three levels of nitrogen (N_0:0,N_{75}:75 and N_{150}:150 kg N ha^{-1})
Three levels of irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage)
Cv: Coefficient of variation

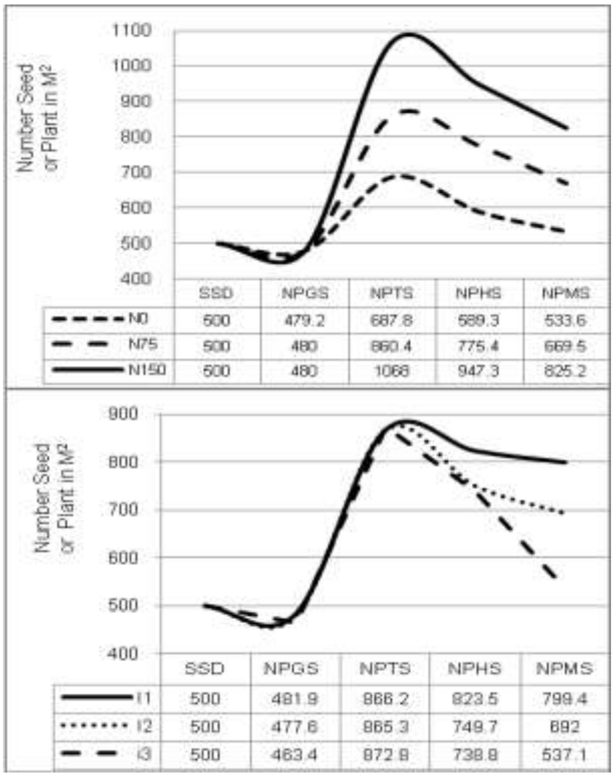

Figure 1- The impact of different nitrogen levels and irrigation regimes on number of plant per meter square.

SSD: Seed Sowing Density (M2);NPGS: Number Of Plant In Germination Stage; NPTS: Number Of Plant In Tillering Stage; NPHS: Number Of Plant In Heading Stage;NPMS: Number Of Plant In Maturity Stage

Three levels of nitrogen (N_0:0, N_{75}:75 and N_{150}:150 kg N ha^{-1})

Three levels of irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage)

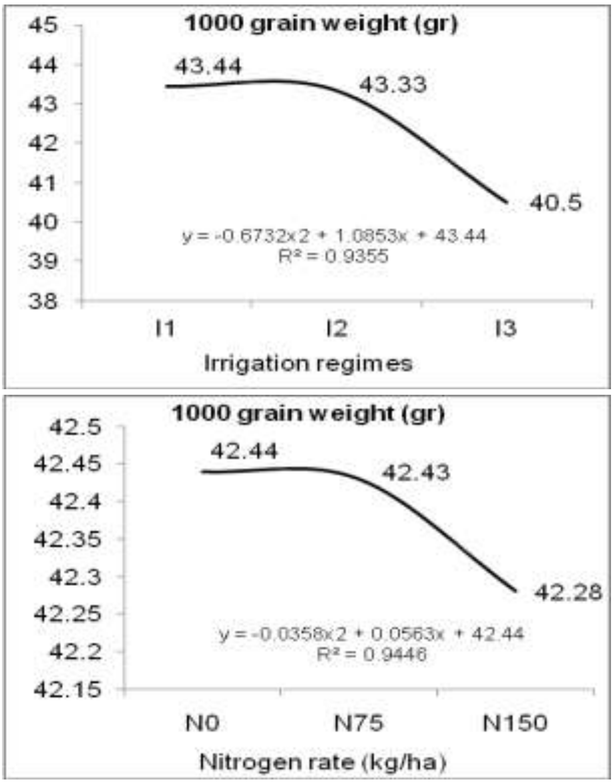

Figure 2: The impact of different nitrogen levels and irrigation regimes on 1000-grain weight.
-Three levels of nitrogen (N_0:0, N_{75}:75 and N_{150}:150 kg N ha^{-1})
-Three levels of irrigation (I_1: regular irrigation in total growth stages, I_2: withholding irrigation at anthesis stage, and I_3: withholding irrigation at seed filling period stage)