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Nitrogen Rate and Timing Implementation on Durum Wheat in a Bed Planting System

(Kadar Nitrogen dan Masa Implementasi pada Gandum Durum dalam Sistem Penanaman Batas)

MEHMET YILDIRIM, ZEKI YAKUT, CUMA AKINCI*, FIRAT KURT & FERHAT KIZILGECI

ABSTRACT

*The effects of nitrogen (N) fertilization at different growth stages were investigated on durum wheat (*Triticum durum* L.) grain yield and yield components (with irrigated bed planting) in Diyarbakir, Turkey. N was applied at a rate of 140 kg ha^{-1} and distributed to one, two and three applications at various combinations with five different growth stages (i.e. sowing, seedling growth, early tillering, stem elongation and booting). This study included 13 treatments, including the control (zero nitrogen). The N application timings (NAT) of the 50% sowing + 50% early tillering and 66% sowing + 33% early tillering treatments were most suitable for durum wheat. The results showed that NAT had significant effect on flowering time, SPAD readings of the early milky ripe stage, plant density, thousand kernel weights, grain filling duration, grain filling rate, grain N content, grain yield, harvest index and grain N yield. In summary, the highest values of parameters studied were obtained from the 50% sowing + 50% first tillering and 66% sowing + 33% early tillering treatments. N fertilization application rate and time of durum wheat genotypes should consist of applying 50-60% of the total N fertilizer at sowing and 40–50% at the early tillering stage under irrigated conditions and with bed planting.*

Keywords: Bed planting system; durum wheat; grain yield; nitrogen timing and rates

ABSTRAK

*Penyelidikan ini mengkaji kesan pembajaan nitrogen (N) pada pelbagai peringkat pertumbuhan hasil bijirin gandum durum (*Triticum durum* L.) dan komponen hasil (dengan pengairan penanaman batas) di Diyarbakir, Turki. N diaplikasi pada kadar 140 kg ha^{-1} dan diagihkan kepada satu, dua dan tiga aplikasi pada pelbagai kombinasi dengan lima peringkat pertumbuhan berbeza (menyemai, pertumbuhan semaian, suli awal, pemanjangan batang dan bunting). Kajian itu merangkumi 13 rawatan, termasuk kawalan (sifar nitrogen). Pemasaan aplikasi N (NAT) dalam 50% penyemaian + 50% suli awal dan 66% penyemaian + 33% rawatan suli awal adalah yang paling sesuai untuk gandum durum. Hasil kajian menunjukkan bahawa NAT mempunyai kesan ketara ke atas masa berbunga, bacaan SPAD untuk peringkat ranum bersusu awal, ketumpatan tanaman, berat seribu isirung, tempoh mengisi bijirin, kadar pengisian bijirin, kandungan bijirin N, hasil bijirin, indeks hasil tuaian dan hasil bijirin N. Kesimpulannya, nilai tertinggi bagi parameter yang dikaji telah diperoleh daripada 50% penyemaian + 50% suli pertama dan 66% penyemaian + 33% rawatan suli awal. Kadar aplikasi pembajaan N dan masa genotip gandum durum perlu menggunakan 50-60% daripada jumlah baja N sewaktu penyemaian dan 40-50% pada peringkat awal suli dalam keadaan pengairan dengan penanaman batas.*

Kata kunci: Gandum durum; hasil bijirin; masa dan kadar nitrogen; sistem penanaman batas

INTRODUCTION

Wheat is grown on more than 240 million ha, larger than any other crop, and world trade is greater than for all other crops combined. The wheat production of the world is 713 million tonnes and of this, 36.4 million tonnes belong to durum wheat. Durum wheat can be grown in limited areas of the world. In recent years, annual wheat grain requirements of developing countries are expected to expand around 1% (Anonymous 2013). The increase in global wheat demand must be supplied by both breeding and management efforts.

Soil has become a substantially depleted resource in global agricultural ecosystems and the development of suitable tillage methods is important for soil protection and long-term soil management. Conventional tillage systems are being replaced by reduced tillage crop management systems, which decrease field traffic, minimize production costs and reduce soil erosion. For example, compared to conventional tillage, bed planting requires less labor, increases soil fertility, increases wheat (*Triticum aestivum* L.) water-use efficiency, controls water and wind erosion and increases plant root depth (Hatfield et al. 1998).

The first bed planting system, developed by Kenned Sayre and O.H. Moreno Ramos at the International Maize and Wheat Improvement Center (CIMMYT) was implemented in 1981 on a flat Mexican terrain. In the Obregon area of Mexico, this planting system was employed on 90% of the cultivated land (Sayre & Ramos 1997). Compared to conventional planting, the bed system provided a 10% increase in yield, 20-30% decrease in production costs and 35% decrease in irrigation water consumption (Sayre et al. 2001). A survey in Mexico reported an average wheat yield of 5.615 kg ha^{-1} for bed planting compared to 4.923 kg ha^{-1} for conventional planting (Aquino 1998). Some researchers found statistically significant differences while comparing bed and other planting methods (Freeman et al. 2007; Karimvand et al. 2013; Mollah et al. 2009; Naresh et al. 2014; Quanqi et al. 2011; Tripathi et al. 2005).

Soil temperature in bed plantings is 2-6°C higher compared to normal planting temperature, accommodating early sowing, rapid germination and early crop development. Prior to implementing the bed system, however, N uptake and efficiency must be measured (Ortega et al. 2008). Nitrogen (N) use efficiency can be increased via plant breeding and improved cultivation practices (Moll et al. 1982). Comparison of crop responses to low and high N doses are useful to compare N uptake efficiency and utilization efficiency of genotypes in a wheat breeding program (Yıldırım et al. 2007).

N rate of 70-90 kg ha^{-1} is recommended for dry conditions in the Southeastern Anatolia region and 140–160 kg ha^{-1} for irrigated conditions (Güçdemir 2006). The frequency and timing of N application affect grain yield, biomass and quality, as well as N concentration and distribution in the soil profile following wheat harvest (Boman et al. 1995). Optimal timing of N application time is associated with N loss potential, which is affected by climate, soil composition, crop species and fertilizer type (Atak et al. 2005). Ayup et al. (2001) reported that the highest wheat yield can be obtained by applying N in three equal parts: At sowing, tillering and flowering. Fertilizer composition also affected their recommendations.

Although phosphorus (P) fertilizers are applied at sowing, N must be applied when the plant needs it (Halaç & Yürür 1999). Darwinkel (1983), found that N, which is typically applied to wheat at the beginning of stem elongation, significantly increases the number of fertile spikes per unit area. Coşkun and Öktem (2004) analyzing the effects of N doses and timing of application on durum wheat yield and yield components, obtained highest yield from sowing time applications compared to applying half at sowing and half at tillering at 120-200 kg/ha N doses. In this study, our goal was to determine the effects of different N rates and application times on wheat grain yield in the bed planting system.

Materials and Methods

Plant Materials and Growth Conditions

This study involved the durum wheat genotypes Sarıçanak-98 cultivar and DUZF-299 advance line. Sarıçanak-98 is spring wheat, with good tillering traits, early to mid-maturity and vulnerable to cold temperatures. DUZF-299 is also spring wheat, early to mid-maturity and vulnerable to cold temperatures. The experiment was conducted at the Dicle University Faculty of Agriculture, Turkey, with a sowing date of December 21, 2009. The location was at 660 m altitude and longitude of 37°54N and 40°14E, respectively.

Climate data of the 2009-2010 season and long-term averages are provided in Table 2. The average temperature (°C), average proportional humidity (%) and total rainfall (mm) of the 2009-2010 seasons were greater than the respective long-term averages. Rainfall in December, when tillering occurs, was below the long-term average. Overall, however, monthly rainfall during the 2009–2010 season was similar to long-term averages. Rainfall was relatively higher in January and lower in February and April. The soil properties of samples taken at a depth of 0–30 cm before planting are presented in Table 3.

Each plot consisted of two beds 70 cm apart. Each bed was sown with 200 seeds/m^2. The experimental design was a split plot design with four replications. N fertilizer application periods were the main plots and genotypes were the subplots. The trial area was irrigated to achieve field capacity at flowering.

N application periods are presented in Table 1. Twelve different N treatments, in addition to a control treatment of no N applied, were used. N was applied one, two or three times, depending on the treatment. Application growth stages were sowing, first leaf formation, early tillering, first node emergence and start of booting. Treatment 2 represented the typical N application practice for the area. N was applied at sowing for the first six treatments and the remaining N was applied at different growth stages. For treatments 7, 8, 9 and 10, the first N application or all N was applied during first leaf emergence and the remaining N was applied at different periods. These four treatments assumed the presence of essential nutrition elements in the seed, but then the plant had not grown sufficiently and most of the N was wasted between sowing and germination, which is typical of cool and wet growing conditions. The effects of delayed N application were examined in treatments 11 and 12.

Crop Sampling and Measurements

Chlorophyll content was measured using a portable chlorophyll meter (SPAD-502; Minolta, Osaka, Japan), which can indirectly measure leaf chlorophyll content. The SPAD measurements were made at the early dough grain development stage. Grain N yield was calculated according to the following formula (Yıldırım et al. 2007):

$$\text{Grain N yield} = \text{Grain yield} \times \text{N content}/100.$$

Statistical Analysis

Analysis of variance (ANOVA) was performed according to a split plot model using SPSS. Differences between treatments and genotypes were analyzed with the Duncan multiple range test.

TABLE 1. Nitrogen fertilizer application time and rates implicated at trial

Nitrogen application timing (NAT)		0:Sowing 22.11.2009	1.1: First leaf formation 04.01.2010	2.1:Early tillering 08.02.2010	3.1:First node formation 02.03.2010	4.1: Early booting 06.04.2010
		Nitrogenous fertilizer application date and ZGS[1] periods				
1) 100% Sowing	TSP[2]	1/1 N[3]	0	0	0	0
2) 50% Sowing + 50% Early tillering	TSP	1/2 N	0	1/2 N	0	0
3) 66% Sowing + 33% Early tillering	TSP	2/3 N	0	1/3 N	0	0
4) 50% Sowing + 50% First node elongation	TSP	1/2 N	0	0	1/2 N	0
5) 33% Sowing + 33% Early tillering + 33% First node elongation	TSP	1/3 N	0	1/3 N	1/3 N	0
6) 33% Sowing + 33% Early tillering + 33% Early booting	TSP	1/3 N	0	1/3 N	0	1/3 N
7) 100% First leaf emergence	TSP	0[4]	1/1 N	0	0	0
8) 50% First leaf emergence + 50% First node elongation	TSP	0	1/2 N	0	1/2 N	0
9) 66% First leaf emergence + 33% First node elongation	TSP	0	2/3 N	0	1/3 N	0
10) 33% First leaf emergence + 33% First node elongation + 33% Early booting	TSP	0	1/3 N	0	1/3 N	1/3 N
11) 100% Early tillering	TSP	0	0	1/1 N	0	0
12) 50% Early tillering + 50% First node elongation	TSP	0	0	1/2 N	1/2 N	0
13) No nitrogen application	TSP	0	0	0	0	0

[1]ZGS: Zadoks Growth Skales
[2]TSP (%42 P_2O_5): Triple Süper Fosfat fertilizer. 70 kg/ha Phosphorus applied with sowing
[3]N Ammonium Nitrate (%33 NH_4NO_3): 140 kg/ha nitrogen applied
[4]0: No Nitrogen Application

TABLE 2. Meteorological data of 2009-2010 growing season and long term averages in Diyarbakir*

Months	Average Temperature (°C)		Rainfall (mm)		Relative Humidity (%)	
	2009-10	LT**	2009-10	LT**	2009-10	LT**
November	9.8	10.0	55.6	54.6	70.6	68.0
December	7.1	4.2	87.2	74.4	83.5	77.0
January	5.4	1.8	113.4	74.6	80.9	77.0
February	6.6	3.6	40.2	68.4	79.9	73.0
March	11.1	8.1	68.7	66.2	66.6	66.0
April	14.2	13.8	22.4	73.5	60.4	63.0
May	20.4	19.3	31.6	40.8	49.3	56.0
June	27.2	28.5	11.2	6.9	29.1	23.0
Average/Total	14.3	12.7	517.9	483.7	59.5	59.4

*:Diyarbakir Regional Directorate of Meteorology records. LT**: Long Term Meteorological Means

TABLE 3. Soil analysis results of experiment area

Structure	Resolved within salt (%)	Lime (%)	Na (%)	pH	Nitrogen (kg/ha)	K_2O (kg/ha)	P_2O_5 (kg/ha)	Organic material (%)
C	0.073	7.81	8.76	7.77	102.0	972.3	4.2	1.67

TABLE 4. The analysis of variance for investigated traits at different nitrogen application timing (NAT) in durum wheat

Source of Variance	D.F.	Flowering time	SPAD	Plant number	Thousand kernel weight	Grain filling duration	Grain filling rate	Grain nitrogen content	Harvest index	Biological yield	Grain yield	Nitrogen yield
Replications	3	0.0	24.1	43.5	2.3	0.0	0.00	0.03	0.0004	66757	6475	3.8*
NAT	12	3.0**	23.2**	474.4**	43.2**	3.0**	0.01**	0.03**	0.0016**	58174	8536**	3.8**
Error	36	2.0	12.1	273.1	30.0	2.0	0.01	0.01	0.0004	47130	4535	2
Genotypes	1	0.0	10.4	116.3	1.1	0.0	0.00	0.04	0.0005	98110	11178	6.4
NAT x Genoype	12	1.3	5.9	204.0	19.1	1.3	0.00	0.01	0.0001	21544	1643	0.6
Error	39	1.1	7.1	155.6	14.1	1.1	0.01	0.01	0.0003	21929	2227	1.0
Coefficient of variation		0.7	5.4	11.8	10.8	2.8	8.6	5.1	6.5	16.2	17.9	19

* Significant at 0.05 level of significance, ** Significant at 0.01 level of significance, DF: Degrees of freedom

TABLE 5. Average value of investigated traits in different nitrogen application timing (NAT) of durum wheat varieties

Nitrogen Application Timing (NAT)	Flowering Time (days)	SPAD	Plant Number (plant/m^2)	Thousand Kernel Weight (g)	Grain Filling Duration (days)	Grain Filling Rate (mg/day)	Grain Nitrogen Content (%)	Harvest Index (%)
1) 100% Sowing	149.0 bc*	50.2 ab	102.6 bcd	34.4 bcd	37.0 bc	0.93 bcd	1.93 de	28.9 ab
2) 50% Sowing + 50% Early tillering	148.1 cd	51.4 a	108.4 abc	38.1 ab	37.9 ab	1.00 ab	2.04 abc	29.0 a
3) 66% Sowing + 33% Early tillering	147.8 d	51.6 a	98.4 cd	39.7 a	38.3 a	1.04 a	1.97 bcde	29.3 ab
4) 50% Sowing + 50% First node formation	149.4 ab	48.6 ab	101.8 cd	33.4 cd	36.6 cd	0.91 cd	1.99 bcd	28.7 ab
5) 33% Sowing + 33% Early tillering + 33% First node formation	149.3 ab	47.3 bc	99.3 cd	33.3 cd	36.8 bc	0.90 cd	1.94 de	27.4 b
6) 33% Sowing + 33% Early tillering + 33% Early booting	149.0 bc	49.0 ab	108.3 abc	34.3 bcd	37.0 bc	0.92 bcd	1.89 e	28.5 ab
7) 100% First leaf formation	149.2 ab	49.1 ab	91.5 d	33.9 cd	36.9 bc	0.92 bcd	1.90 de	29.3 a
8) 50% First leaf formation + 50% First node formation	148.6 bcd	49.8 ab	105.3 bc	36.4 abc	37.4 abc	0.97 abc	2.01 abcd	28.6 ab
9) 66% First leaf formation + 33% First node formation	149.1 bc	48.9 ab	110.6 abc	34.1 cd	36.9 bc	0.92 bcd	2.10 a	29.3 ab
10) 33% First leaf formation + 33% First node formation + 33% Early booting	150.3 a	45.2 c	101.9 cd	30.9 d	35.8 d	0.86 d	2.00 a	24.0 c
11) 100% Early tillering	148.8 bcd	49.5 ab	99.8 cd	34.7 bcd	37.3 abc	0.93 bcd	1.96 bcd	28.3 ab
12) 50% Early tillering + 50% First node formation	148.5 bcd	50.5 a	120.8 a	36.4 abc	37.5 d	0.97 abc	2.11 a	29.4 a
13) No nitrogen application	149.1 bc	48.3 ab	114.9 a	32.9 cd	36.9 bc	0.89 cd	2.10 a	29.2 ab

* Means followed by the same letter in the same column are not different

TABLE 6. Average value of biologic yield, grain yield and nitrogen yield in different nitrogen application timing (NAT) of durum wheat genotypes

Nitrogen Application Methods (NAT)	Biological Yield (kg/da)			Grain Yield (kg/da)			Nitrogen Yield (kg/da)		
	DUZF-299	Sarıçanak 98	Average	DUZF-299	Sarıçanak 98	Average	DUZF-299	Sarıçanak 98	Average
1) 100% Sowing	822.9	1005.6	914.2 abc*	237.2	291.1	264.1 abc	4.68	5.51	5.09 ab
2) 50% Sowing + 50% Early tillering	980.3	1014.3	997.3 ab	292.2	294.8	293.4 ab	5.86	6.08	5.97 a
3) 66% Sowing + 33% Early tillering	1060.8	1047.4	1054.1 a	308.9	305.4	307.1 a	6.12	6.01	6.06 a
4) 50% Sowing + 50% First node formation	849.6	872.5	861.0 bcd	244.8	251.3	248.0 bc	4.88	5.02	4.95 b
5) 33% Sowing + 33% Early tillering + 33% First node formation	759.9	891.9	825.9 cd	213.1	249.4	231.2 c	4.18	5.01	4.59 b
6) 33% Sowing + 33% Early tillering + 33% Early booting	835.1	1081.9	958.5 abc	236.3	310.4	273.3 abc	4.43	5.90	5.16 ab
7) 100% First leaf formation	937.2	886.5	911.9 abc	276.2	259.6	267.8 abc	5.20	4.99	5.10 ab
8) 50% First leaf formation + 50% First node formation	947.3	963.6	955.4 abc	266.0	282.1	274.0 abc	5.40	5.64	5.52 ab
9) 66% First leaf formation + 33% First node formation	841.9	955.7	898.8 bc	244.5	283.3	263.8 abc	5.14	5.82	5.48 ab
10) 33% First leaf formation + 33% First node formation + 33% Early booting	777.4	646.5	711.9 d	182.0	166.4	174.1 d	3.44	3.44	3.44 c
11) 100% Early tillering	869.2	1038.9	954.1 abc	244.4	300.6	272.5 abc	4.64	6.13	5.39 ab
12) 50% Early tillering + 50% First node formation	951.7	979.0	965.4 abc	279.9	287.2	283.5 ab	5.70	6.24	5.97 a
13) No nitrogen application	856.2	904.0	880.1 bc	250.0	263.6	256.7 bc	5.15	5.47	5.31 ab
Average	883.8 b	945.2 a		272.7 a	251.9 b		4.98 a	5.48 b	

* Means followed by the same letter in the same column are not different

Results and Discussion

All NAT traits, except for biological yield, were significantly affected by the N application treatments (Table 4). Genotypes and NAT × genotype interaction effects were not significant. The average flowering time of durum wheat genotypes varied from 147.8 to 150.3 days over different treatments and the earliest flowering date was obtained from the 66% sowing + 33% early tillering treatment (Table 5). Kiliç (2010) reported that chlorophyll contents of wheat varieties in bed planting method were higher than flat planting method. The SPAD measurements collected at stem elongation and heading periods were not significantly different. At the early dough stage, the highest SPAD values were obtained from the 66% sowing + 33% early tillering and 50% sowing + 50% early tillering treatments (Table 5).

The weight of grains per spike and number of plants per m^{-2} were higher in bed planting system (Hossain et al. 2006; Kiliç 2010). The number of plants per m^{-2} ranged from 91.5 to 120.8 plants. The maximum number of plants/m^2 was obtained from the 50% early tillering + 50% first node formation treatment. The maximum average thousand kernel weight value was obtained from the 66% sowing + 33% early tillering treatment (Table 5). Generally, dividing N into two applications gave higher thousand kernel weights compared with one or three applications.

According to studies conducted by Kiliç (2010), Hossain et al. (2006) and Özberk et al. (2009), thousand kernel weights increased significantly in bed planting system. Thousand kernel weights of NAT treatments 4, 5 and 10 NATs were similar to or less than the treatment of no N (treatment 13). N application at sowing provided more time for grain filling period compared to that of delayed N application. The longest grain filling period was recorded for the 66% sowing + 33% early tillering treatment. The 66% sowing + 33% early tillering treatment also gave the highest grain filling rate (Table 5). Grain filling was faster as a result of two separate N applications compared to a single or three N applications. When a single N application was compared to three applications, the single application was superior. Grain filling rate was less for no N applied (treatment 13) compared to treatments 4 and 5.

Khaleque et al. (2008) reported that on account of higher uptakes of nitrate nitrogen and collection of more solar radiation along with carbon dioxide grain and straw N content was the highest in bed planting system 2.13 and 0.33%, respectively. The highest durum wheat grain N content was obtained from the 50% early tillering + 50% first node treatment. Dividing N into two applications resulted in higher N content in the grain compared to one application or dividing the same amount of N into three applications. Grain N contents of treatments 2 and 9 were similar to that of treatment 13 (Table 5). Limon-Ortega et al. (2000) stated that 150 kg N ha^{-1} nitrogen level is the most stable N application rate within all environments at the first node stage.

The highest harvest index was obtained from the 50% early tillering + 50% first node formation treatment. Dividing the N fertilizer into two applications resulted in a harvest index greater than treatments involving one or three applications. The harvest index was superior for one N application compared to three applications. Harvest index values of treatments 3, 7 and 9 were similar to or lower than that of treatment 13 (Table 5).

There were several reports and studies reporting that bed planting system influences grain yield (Alam 2012; Bhuyan et al. 2012; Connor et al. 2003; Hossain et al. 2006, 2004). The average of grain and biological yield values are presented in Table 6. The highest yield was obtained from the 66% sowing + 33% early tillering treatment. Yields from two N applications were generally better than of one or three applications. Additionally, grain yield of one application was superior to three applications of N. The grain and biological yields of treatments 4, 5 and 10 were similar to or lower than that for treatment 13. Ortega et al. (2008) reported that the timing of N application did not affect the bread wheat grain yield when cultivated on a bed planting system. Limon-Ortega et al. (2000) reported that regardless of time of nitrogen application while nitrogen rate increased, wheat produced higher grain yields in high yielding environments. However, in low yielding environments wheat did not respond to increased nitrogen rates.

The highest N yield was obtained from 66% sowing + 33% early tillering NAT (Table 6). Generally, dividing N fertilizer into two applications provided greater N yield compared to one application or dividing N to three applications. Additionally, one N application was superior to three applications. The N yields of treatments 6, 7, 8, 9 and 11 were similar to or lower than that of treatment 13.

Conclusion

The highest grain yield was obtained from 66% sowing + 33% early tillering NAT. Grain yield was generally greater for treatments consisting of two N applications compared to the treatments of one or three applications. Dividing N fertilizer into two applications (at sowing and tillering) is compatible with common management practices of the Diyarbakir region. If irrigation is not an option, applying all the N fertilizer at sowing is more suitable during dry seasons. In conclusion, the highest values from parameters studied here were obtained from the 50% sowing + 50% first tillering and 66% sowing + 33% early treatments. N application rate and time of durum wheat genotypes should consist of applying 50–60% of the total N fertilizer at sowing and 40–50% at the early tillering stage under irrigated conditions and with bed planting.

References

Aquino, P. 1998. The adaptation of bed planting of wheat in the Yaqui Valley, Sonora, Mexico. *CIMMYT Wheat Program Special Report 17A*.

Alam, M.S. 2012. Effect of sowing patterns and nitrogen rates on quality traits and yield of wheat. *Journal of Environmental Science and Natural Resources* 5: 267-272.

Anonymous. 2013. International Grains Council, Five-year Global Supply and Demand Projections. 10 December 2013, p. 2.

Atak, M., Kaya, M. & Çiftçi, C.Y. 2005. Kızıltan-91 makarnalık buğday çeşidinde farklı azotlu gübreler ile uygulama şekillerinin verim ve bazı verim özelliklerine etkileri. *Türkiye VI. Tarla Bitkileri Kongresi,* 5-9 Eylül 2005, Cilt I, 121-126, Antalya.

Ayup, M., Sharar, M.S., Tanveer, A. & Khaliq, M. 2001. Growth and yield response of wheat (*Triticum aestivum* L.) to nitrogen application at different growth stages. *Journal of Biological Sciences* 1: 92-94.

Bhuyan, M.H.M., Ferdousi, M.R. & Iqbali, M.T. 2012. Foliar spray of nitrogen fertilizer on raised bed increases yield of transplanted aman rice over conventional method. *International Scholarly Research Network Agronomy* Article ID 184953.

Boman, R.K., Westerman, R.L., Raun, W.R. & Jojola, M.E. 1995. Time of nitrogen application: Effects on winter wheat and residual soil nitrate. *Soil Science Society of America Journal* 59: 1364-1369.

Connor, D.J., Timsina, J. & Humphreys, E. 2003. Prospects for permanent beds for rice-wheat systems. In *Improving the Productivity and Sustainability of Rice-Wheat Systems: Issues and Impacts,* edited by Ladha, J.K., Hill, J.E., Duxbury, J.M., Gupta, R.K. & Buresh, R.J. Madison, Wisconsin: ASA Special Publication 65. pp. 197-210.

Coşkun, Y. & Öktem, A. 2004. Farklı dozlarda ve zamanlarda uygulanan azotun makarnalık buğdayda (*Triticum durum* Desf.) verim ve verim unsurlarına etkisi. *Harran Üniversitesi Ziraat Fakültesi Dergisi* 7: 1-10.

Darwinkel, A. 1983. Ear formation and grain yield of winter wheat as affected by time of nitrogen supply. *Netherland Journal of Agricultural Science* 31: 211-225.

Freeman, K.W., Klatt, A.R., Raun, W.R., Girma, K., Arnall, D.B., Tubana, B., Holtz, S.L., Lawles, K.D., Walsh, O., Chung, B. & Sayre, K.D. 2007. Bed and flat planted dryland winter wheat as influenced by row configuration. *Archives of Agronomy and Soil Science* 53: 293-304.

Güçdemir, İ.H. 2006. *Türkiye gübre ve gübreleme rehberi*. Tarım ve Köy İşleri Bakanlığı, Tarımsal Araştırmalar Genel Müdürlüğü, Toprak ve Gübre Araştırma Enstitüsü Müdürlüğü. Genel Yayın No. 231, Ankara.

Halaç, İ. & Yürür, N. 1999. Azotlu gübre verme zamanlarının buğdayın verim ve kalitesine etkisi. *Türkiye 3. Tarla Bitkileri Kongresi,* 15-18 Kasım 1999, 145-150, Adana.

Hatfield, J.L., Allmaras, R.R., Rehm, G.W. & Lowery, B. 1998. Ridge tillage for corn and soybean production environmental quality impacts. *Soil and Tillage Research* 48: 145-154.

Hossain, M.I., Islam, M.K., Sufian, M.A., Meisner, C.A. & Islam, M.S. 2006. Effect of planting method and nitrogen levels on the yield and yield attributes of wheat. *Journal of Biological Science* 14: 127-130.

Hossain, M.I., Meisner, C., Duxbury, J.M., Lauren, J.G., Rahman, M.M., Meer, M.M. & Rashid, M.H. 2004. Use of raised beds for increasing wheat production in rice-wheat cropping systems. *12th AAC. 4th ICSC. Water. Irrigated Rice-based Systems 5ACSC*.

Karimvand, P.N., Nejad, T.S. & Shokohfar, A.R. 2013. The effects of basin, ridge and furrow planting methods on yield components of cowpeas at different irrigation levels. *International Journal of Agriculture and Crop Science* 6: 1407-1412.

Khaleque, M.A., Paul, N.K. & Meisner, C.A. 2008. Yield and N use efficiency of wheat as influenced by bed planting and N application. *Bangladesh Journal of Agricultural Research* 33: 439-448.

Kiliç, H. 2010. The effect of planting methods on yield and yield components of irrigated spring durum wheat varieties. *Scientific Research and Essays* 5: 3063-3069.

Limon-Ortega, A., Sayre, K.D. & Francis, C.A. 2000. Wheat and maize yields in response to straw management and nitrogen under a bed planting system. *Agronomy Journal* 92: 295-302.

Moll, R.H., Kamprath, E.J. & Jackson, W.A. 1982. Analysis and interpretation of factors which contribute to efficiency to nitrogen utilization. *Agronomy Journal* 74: 562-564.

Mollah, M.I.U., Bhuiya, M.S.U. & Kabir, M.H. 2009. Bed planting - a new crop establishment method for wheat in rice-wheat cropping system. *Journal of Agriculture and Rural Development* 7: 23-31.

Naresh, R.K., Tomar, S.S., Purushottam Singh, S.P., Kumar, D., Pratap, B., Kumar, V. & Nanher, A.H. 2014. Testing and evaluation of planting methods on wheat grain yield and yield contributing parameters in irrigated agro-ecosystem of western Uttar Pradesh, India. *African Journal of Agricultural Research* 9: 176-182.

Ortega, L., Villaseñor-Mir, E. & Espitia-Rangel, E. 2008. Nitrogen management and wheat genotype performance in a planting system on narrow raised beds. *Cereal Research Communications* 36: 343-352.

Özberk, İ., Coşkun, Y., Ilkhan, A., Köten, M., Karli, B. & Ryan, J. 2009. Comparison of bed planting-furrow irrigation with conventional planting-flood irrigation in durum wheat (*T. durum* Desf.) in Southeastern Turkey. *Pakistan Journal of Biological Science* 12: 772-778.

Quanqi, L., Yuhai, C., Xunbo, Z. & Songlie, Y. 2011. Effects of deficit irrigation and planting modes on leaves' water physiological characteristics and grain yield of winter wheat. *New Technology of Agricultural Engineering (ICAE), 2011 International Conference* on 27-29 May. pp. 305-308.

Sayre, K.D., Mezzalama, M. & Martinez, M. 2001. Tillage, crop rotation and crop residue management effects on maize and wheat production for rainfed conditions in altiplano of central Mexico. *Conservation Agriculture, A Worldwide Challenge. First World Congress on Conservation Agriculture*, Madrid, Spain. 1-5 October. Volume 2: offered contributions. pp. 575-580.

Sayre, K.D. & Ramos, O.H.M. 1997. Applications of raised-bed planting systems to wheat. *CIMMYT Wheat Program Special Report* WPSR No: 31.

Tripathi, S.C., Sayre, K.D. & Kaul, J.N. 2005. Planting systems on lodging behavior, yield components, and yield of irrigated spring bread wheat. *Crop Science* 45: 1448-1455.

Yıldırım, M., Bahar, B., Genç, İ., Korkmaz, K. & Karnez, E. 2007. Diallel analysis of wheat parents and their F_2 progenies under medium and low level of available n in soil. *Journal of Plant Nutrition* 30: 937-945.

Mehmet Yildirim, Zeki Yakut & Cuma Akinci*
Dicle University, Faculty of Agriculture
Department of Field Crops, Diyarbakir
Turkey

Firat Kurt
Mus Alparslan University

Malazgirt Vocational School, Mus
Turkey

Ferhat Kizilgeci
Sırnak University, Faculty of Agriculture
Department of Field Crops, Sırnak
Turkey

*Corresponding author; email: akinci@dicle.edu.tr

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