

EFFECT OF NITROGEN FERTILIZERS (2) ON QUALITY CHARACTERISTICS OF WHEAT CROP

by

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Abstract

An experiment was conducted to see the effect of nitrogen fertilizers, rates and time of application on some quality characteristics of wheat crop grown at Enstitu and Guneli locations, Eskişehir, Turkey. Rates of 0, 60 and 120 kg N/ha were used in this experiment. Half of these rates in the shape of ammonium sulphate (20 % N) were applied at the time of sowing and in the second half these rates were applied as Calcium ammonium nitrate (26 % CAN) and urea (46 %) at four different times that is 20th Feb., 20th March., 20th April and 20th. of May. In addition to this P as triple super phosphate (42-44 % P₂O₅) was also applied before sowing for the normal growth of the crop. Experimental design used was randomised complete block split-split plot with four replications. The results showed, that both N fertilizers have increased the biologic yield of wheat. The N rates have significant effect on the chlorophyll content of leaves, on the sedimentation value of grain, N-content and N-uptake of grain and on protein content of grain. Nitrogen fertilizer rates have significantly affected the wheat straw N content and N-uptake also.

Key words

Biologic yield, chlorophyll, N-content, N-uptake, protein content, soil NH₄ and NO₃-N

1.- Introduction

Wheat is a major commodity in the world. Bread is one of the major products from wheat. Wheat grain quality generally depends on protein, starch and lipid content of grain. Like in most of the world countries, it is also very important food nutrient in Turkey. Depending on the standard of living of the people. the consumption of wheat as a bread in the world varies between 41-301 Kg / year. Whereas in Turkey it varies between 180-201Kg/year as reported by VANGÖL (1999). The consumption of different food products obtained from wheat is also increasing everyday.

The main object of this research work is to see the effect of nitrogen fertilizers, on the biologic yield, leaf chlorophyll content, wheat grain sedimentation value, grain N-content and N-uptake, protein percent of grain and NH₄-N and NO₃-N content of soil after the harvest of wheat crop, when applied in spring to winter wheat grown at two locations of Eskişehir in Turkey.

2.- Materials and methods

Kırgız 95 bread wheat variety was used. This variety is heavy, light brown coloured, white grain with 100-110 cm in height, 32-35 gr./1000 grain weight, 78-80 kg hectolitre weight, 11-14 % protein and resistance to rust. The experiment was continued for two consecutive years at two locations that is Enstitu and Güneli. Two nitrogen fertilizers (calcium ammonium nitrate and urea) with 3 rates and 4 times of application were used in this study. The factors are as under:

- A. Time of applications: 20th. Feb.; 20th. March; 20th. April and 20th of May.
- B. N-fertilizers are: 26% CAN and 46% urea
- C. Rates: 0. 60. and 120 Kg N/ha

Half of the nitrogen was applied before sowing as an ammonium sulphate to all plots except control. The second half of the nitrogen was applied as calcium ammonium nitrate (CAN) and urea at four different times. P at the rate of 70 kg P₂O₅ Kg /ha was applied as triple super phosphate (42-44 % P₂O₅) to all plots for optimum growth of the crop.

3.- Results and discussion

Effect of N fertilizers, rates and time of application on biologic yield of wheat crop

The effect of N fertilizers on the biologic yield of wheat crop is given in table 1

Type of Fertilization	Rate kg/ha	Time of application									
		February		March		April		May		Av. Rate.	
		Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli
A. Nitrate	0	6000 g	8930	8500d-f	7240	6700 ef	8590	8700 de	9000	7480 c	8440
	60	11000a-c	12150	9000cd	11150	11250 ab	11480	11550ab	13500	10700 b	12070
	120	12200 ab	13060	11400ab	12610	12500 a	12640	11450ab	12650	11890 a	12740
	Av..	9730	11380	9630	10330	10150	10900	10570	11710	10020	11080
A.Nitrate Av..		Enstitü 2002		1002		Güneli 2002		1108			
Urea	0	6650e-g	7820	5350 g	8970	6050 g	7290	6450fg	9270	6130 d	8340
	60	11300a	12270	10950ac	14270	11700ab	12790	11750ab	14610	11430 ab	13480
	120	10300bd	11460	12500 a	13020	12150ab	12410	11900ab	13180	11710 ab	12520
	Av..	9420	10520	9600	12090	9970	10830	10030	12350	LSD (Rate)	
Urea Av..		Enstitü 2002 Güneli 2002		9750 11440		Ens-02 LSD(F x R):102,91 Ens-02 LSD(TxFx R)=205,26				Enstitü	Güneli
Time Av..		9580	10950	9620	11210	10060	10870	10300	12030	72,5**	106,10**
Rate	0	6330	8370	6930	8100	6380	7940	7580	9130	680 0c	8390 b
	60	11150	12210	9980	12710	11480	12130	11650	14050	11060 b	12780 a
	120	11250	12260	11950	12810	12330	12520	11680	12910	1180 0a	12630 a

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 1.- Effect of N fertilizers, rates and time of application on the biologic yield of wheat crop (kg/ha)

As it is seen in table 1, that both N fertilizers have increased the biologic yield of wheat on both locations. But the yields were a bit higher in second year as compared to first year. Increasing rates have increased the biologic yields when compared to control treatment. GELETO (1994) has also found out increased biologic yields of wheat when N fertilizers were applied at tillering stage. The difference in yields of two locations might be due to the fact of different amount of precipitation and of different physical and chemical properties of the locations.

• Effect of N fertilizers, rates and time of application on chlorophyll content of wheat crop

The N rates have significant affect (up to 1% level) on the chlorophyll content of wheat crop. Whereas time of application and rate interaction effect was significant up to 5 % level. Time of fertilizer application and type of fertilizers have no significant effect on the chlorophyll content of wheat. A chlorophyll of 40.0, 43.2 and 43.9 Spad was obtained for the year 2001 and chlorophyll of 29.2, 36.2 and 39.8 Spad was obtained for the year 2002 at Enstitü location for 0, 60 and 120 Kg N/ha rates respectively. At Güneli location for the year 2002, a chlorophyll of 31.2, 41.0 and 44.2 Spad was obtained for 0, 60 and 120 Kg N/ha rates respectively. No determinations of chlorophyll were made during the year 2001 at Güneli location. Effect of rates was significant when compared to control but non significant between each other (table 2).

The difference between two years at Enstitü location might be due to the fact of difference in soil and climatic characteristics. Chlorophyll determinations are the best way to make N fertilizer recommendations. Hence calibrations between chlorophyll content and N rates must be made for each variety at different soil texture and at different climatic conditions. LLOYD *et al.* (2004) have carried out chlorophyll determinations of flag leaf and recommended the following formula for N fertilizer rates for wheat crop: $N = 6 + (7 \times D)$; $D = (\text{chlorophyll reading done in control treatment plants} - \text{chlorophyll reading done in highest N rate plants})$.

Type of Fertilizer	Enstitü location		Güneli location	
	2001	2002	2002	Av.
A.Nitrate	42,3	35,5	39,0	38,9
Urea	42,5	34,7	38,5	38,5
Time of Application	N.S	N.S	N.D	
February	43,1	33,7	38,5	38,5
March	41,6	35,1	38,8	38,5
April	42,9	37,0	39,1	39,7
May	41,9	34,4	38,8	38,3
Rates Kg/ha	Ö.D	Ö.D	Ö.D	
0	40,0 b	29,2 c	31,2 c	33,5
60	43,2 a	36,2 b	41,0 b	40,1
120	43,9 a	39,8 a	44,2 a	42,6
Av.	42,41	35,10	38,8	
CV, %	4,77	11,39	8,17	
LSD	1,01**	1,12**	1,44**	

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 2.- Effect of N fertilizers, rates and time of application on chlorophyll value of wheat crop (spad)

Effect of nitrogen fertilizers, rates and time of application on sedimentation value of wheat grain

Type of Fertilizer	Enstitü location		Güneli location		Av.
	2001	2002	2001	2002	
Ammonium nitrate	12.29	8.01	12.48	10.26	10.76
Urea	12.97	7.85	12.80	10.02	10.91
Time of application	N.S				
February	12.60	7.50	12.60	9.71	10.60
March	12.21	7.50	12.85	9.52	10.52
April	12.77	8.71	13.00	10.23	11.18
May	12.94	8.02	12.10	11.10	11.04
Rate kg N/ha)	N.S				
0	11.53 b	6.48 c	11.23 b	8.38 c	9.41
60	12.88 a	7.70 b	13.13 a	10.14 b	10.96
120	13.48 a	9.61 a	13.56 a	11.91 a	12.14
Av.	12.63	7.93	12.64	10.14	
CV. %	10.68	16.82	8.8	19.29	
LSD	0.678**	0.67**	0.559**	0.983**	

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 3.- Effect of N fertilizers, rates and time application on the sedimentation value of wheat grain (ml)

The N fertilizer rates have a significant effect (1% level) on the sedimentation value of wheat grain. A sedimentation value of 11.53, 12.88 and 13.48 ml for the year 2001 and a sedimentation value of 6.48, 7.70 and 9.61 ml for the year 2002 was obtained at Enstitü location. Whereas a sedimentation value of 11.23, 13.13 and 13.56 ml for the year 2001 and a sedimentation value of 8.38, 10.14 and 11.91 ml for the year 2002 was obtained at Güneli location (table 3). 60 kg N/ha rate has significantly increased the sedimentation value of wheat grain. LIOVERAS *et al.* (2001) have reported that the quality of bread wheat depends on the variety and on the use of nitrogen fertilizers. These results are in consistence with the results of OORO *et al.* (1999).

Effect of N fertilizers, rates and time of application on n content of wheat grain

The N fertilizers rates have significantly (at 1 % level) affected the N content of wheat crop grown at two locations (table 4). N fertilizers increased the grain N content in 2001 than 2002.

Type of fertilizer	Enstitü location		Güneli location		Ort.
	2001	2002	2001	2002	
Ammonium Nitrate	1.68	1.47	1.73	1.67	1.64
Urea	1.66	1.43	1.74	1.66	1.62
Time of application	N.S				
February	1.70	1.41	1.71	1.65	1.62
March	1.68	1.41	1.73	1.67	1.62
April	1.62	1.48	1.77	1.67	1.64
May	1.64	1.52	1.73	1.68	1.64
Rate kg N/ha	N.S				
0	1.54 c	1.30 c	1.66 c	1.45 c	1.49
60	1.65 b	1.43 b	1.72 b	1.65 b	1.61
120	1.81 a	1.63a	1.82 a	1.90 c	1.79
Av.	1.67	1.45	1.73	1.67	
CV. %	3.7**	5.28**	3.84**	6.52**	

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 4.- Effect of N fertilizers, their rates and time of application on the n content of wheat grain (%)

This might be due to the fact that the N fertilizers increased the grain yield in 2002. This increase caused the dilution of N content. Late N fertilizer application have generally increased the N content of grain except in year 2001 at Enstitü location. These results are in an agreement with the results of GELETO (1994), WUEST and CHASSMAN (1992), VAUGHAN *et al.* (1990 a and b).

Effect of N fertilizers, rates and time of application on protein content of grain wheat

Nitrogen fertilizer rates have significantly affected the grain protein content. A protein content of 9.66, 10.31, and 11.30 % was obtained at 0, 60 and 120 Kg N / ha rate respectively at Enstitü location for the year 2001. A protein content of 8.15, 8.92, and 10.20 % was obtained at 0, 60 and 120 Kg N / ha rate respectively at Enstitü location for the year 2002. Similar results were also obtained at Güneli location for both the years (table 5) and interaction among time of nitrogen application, type of fertilizer, and fertilizer rates was calculated up to 5 % level for the first year. However in the next year a significant interaction was calculated between time of application and fertilizer rates up to 1 % level. A protein content of 10.61 %, 10.50 %, 10.30 % and 10.20 % for the year 2001 and 8.79 %, 8.80 %, 9.25 % and 10.60 % for the year 2002 was obtained at Enstitü location for February, March, April and May applications respectively. Similarly a protein content of 10.68 %, 10.82 %, 11.04 % and 10.83 % was obtained for the year 2001 and a protein content of 10.32 %, 10.45 %, 10.41 % and 10.52 % was obtained for the year 2002 at Güneli location (table 5). In general late nitrogen application has increased the protein content than the early application. Since protein content of the grain is affected more by nitrogen application as has been reported by STANFORD and HUNTER (1973), KALAYCI *et al.* (1996) and SADE *et al.* (1995). At Enstitü location, the protein content % was more in first year than in second year.

Type of fertilizer	Enstitü location		Güneli location		Ort.
	2001	2002	2001	2002	
Ammonium nitrate	10.47	9.19	10.81	10.46	10.24
Urea	10.36	8.96	10.87	10.39	10.15
Time of application	N.S				
February	10.61	8.79	10.68	10.32	10.10
March	10.50	8.80	10.82	10.45	10.14
April	10.30	9.25	11.04	10.41	10.25
May	10.20	10.60	10.83	10.52	10.27
Rate kg N/ha)	N.S				
0	9.66 c	8.15 c	10.39 c	9.06 c	9.32
60	10.31 b	8.92 b	10.73 b	10.34 b	10.08
120	11.30 a	10.20 a	11.41 a	11.87 a	11.18
Av.	10.42	9.08	10.84	10.42	
LSD	0.194**	0.298**	0.207**	0.337**	
CV. %	3.7	5.25	3.8	6.46	

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 5.- Effect of nitrogen fertilizers, rates and time of application on the protein content of wheat grain (%)

This might be due to the fact that the late application of nitrogen fertilizers supported the plant to take more nitrogen and this in turn has increased the protein content of wheat crop. Similar results were also obtained by BAETHGEN and ALLEY (1989).

Effect of N fertilizers, rates and time of application on wheat grain n uptake

Nitrogen fertilizer rates have significantly affected the wheat grain N uptake when compared to control treatment. No significant interaction was obtained between application time and fertilizer type (table 6).

Fertilizer Type	Rate Kg N/ha	Time of application									
		February		March		April		May		Rate Av.Doç	
		Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli
A.Nitrate Kg N/ha	0	30.1	45.7	31.1	38.9	31.2	48.8	46.2	41.5	34.7	43.7
	60	44.5	67.6	41.6	58.9	48.2	68.7	61.7	61.5	49.0	64.2
	120	53.9	67.6	57.0	68.0	65.6	73.2	61.1	77.3	59.4	71.5
	Ort.	42.8	60.3	43.2	55.3	48.3	63.6	56.3	60.1	47.7	59.8
A.Nitrate Av..		Enstitü 2002		47.7		Güneli 2002		59.8		LSD (F xR)Enstitü 6.8*	
Urea kg N/ha	0	35.2	46.7	30.8	48.1	35.8	40.8	31.1	44.4	33.2	45.0
	60	47.5	58.2	44.6	70.4	56.6	60.2	51.5	61.0	50.0	62.4
	120	506.0	690.0	563.0	763.0	633.0	689.0	515.0	755.0	554.0	724.0
	Ort.	4,44	5,80	4,39	6,49	5,19	5,66	4,47	6,03	LSD (Rate)	
Urea Av..		Enstitü 2002		46.2		Güneli 2002		59.9		Enstitü	Güneli
Time Av..		43.6	59.1	43.6	60.1	50.1	60.1	50.5	60.2	3.4**	4.0**
Rate Kg N/ha	0	32.7 fg	46.2	31.0 g	43.5	33.5 fg	44.8	38.6 ef	43.0	33.9 c	44.4 c
	60	46.0cd	62.9	43.1 de	64.6	52.4bc	64.4	56.6 b	61.2	49.5 b	63.3 b
	120	52.2bc	68.3	56.6 b	72.1	64.4 a	71.1	56.3 b	76.4	57.4 a	72.0 a

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 6.- Effect of N fertilizers, rates and time of application on grain n-uptake (kg n/ha)

Generally late N applications have increased the grain N uptake when compared to early application. Similar results were also obtained by JANZEN *et al.* (1991).The split applications of N fertilizer have increased the grain N uptake as have been reported by ALCOZ *et al.* (1993), SOWERS *et al.* (1994), AYOUB *et al.*

(1994). Grain N uptake generally depends on grain yield and on grain N content. A highest grain N uptake of 495.00 and 574.0 Kg N/ha was obtained at Enstitü location for 60 and 120 Kg N/ha rates respectively (table 6), whereas a highest grain N uptake of 633.0 and 720.0 Kg N/ha was obtained at Güneli location for 60 and 120 Kg N/ha rates respectively.

Effect of N fertilizers, rates and time of application on n content of wheat straw

The effect of nitrogen fertilizers, rates and application time on the N content of wheat straw is given in table 7.

Fertilizer Type	Enstitü location		Güneli location		Av..
	2001	2002	2001	2002	
Ammonium Nitrate	0,37	0,33	0,36	0,38	0,36
Urea	0,37	0,32	0,37	0,38	0,36
Time Of application	N.S				
February	0,37	0,32	0,36	0,38	0,36
March	0,37	0,34	0,37	0,37	0,36
April	0,38	0,32	0,38	0,38	0,37
May	0,37	0,32	0,37	0,39	0,36
Rate kg N/ha	N.S				
0	0,37	0,33	0,39 a	0,39	0,37
60	0,38	0,32	0,36 b	0,37	0,36
120	0,38	0,32	0,35b	0,38	0,36
Av.	0,38	0,32	0,37	0,38	
CV, %	6,45	8,21	6,84	8,26	

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 7.- The Effect of N fertilizers, rates and time of application on the n content of wheat straw (%)

Nitrogen fertilizers have no significant effect on the N content of straw. The values for the first year on both locations generally was more than the second year. Similar results were also obtained by CHRISTENSEN and MEINTS (1982), MEELU *et al.*(1987), OTTMAN *et al.*(2000b).

The workers like SPRATT (1974) and GELETO (1994) also found out no different effect of N fertilizers on the N content of straw in their studies. Our results are in an agreement with their results. N rates have generally decreased the N content of straw when compared to control. This might be due to the increased straw yield which in turn caused the dilution of the N content in the straw. Similar results were also obtained by CHRISTENSEN and MEİNTS (1982), GELETO (1994).

Effect of N fertilizers, rates and time of application on wheat straw N uptake

Nitrogen fertilizer rates have significantly affected the wheat straw N uptake when compared to control treatment (table 8). These results are in confirmation with the results of CHRISTENEN and MEINTS (1982), MEELU *et al.* (1987), GRAVELLE *et al.* (1988), JANZEN *et al.* (1991) and GELETO (1994).

No significant interaction was obtained among time of application, type of fertilizer and fertilizer rates. Wheat straw N uptake of 132.0, 135.0, 155.0 and 165.0 Kg N/ha was obtained at Enstitü location and 165.0, 173.0, 167.0 and 185.0 Kg N/ha was obtained at Güneli location for 20th February, 20th March, 20th April and 20th May application respectively. Similar results were obtained by CHRISTENEN AND MEINTS (1982), MEELU *et al.* (1987), GRAVELLE *et al.* (1988), JANZEN *et al.* (1991) and GELETO (1994).

Effect of N fertilizers, rates and time of application on NH₄-N content of the soil after wheat harvest

The soil analysis after harvest of the wheat crop was done only on the Enstitü location. The soil samples were collected at 0-30 cm depth. The data regarding the soil ammonium content after harvesting is given in table 9. As it is seen in table 9, that 6.67, 8.37 and 8.00 ppm NH₄⁺N in year 2001 and 5.98, 9.29 and 9.08 ppm NH₄⁺N in year 2002 was obtained at 0, 60 and 120 Kg N/ha rates respectively. The highest NH₄⁺N was obtained at 60 Kg N/ha rate in both years.

Fertilizer Type	Rate Kg N/ha	Time of application									
		February		March		April		May		Rate Av.	
		Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli	Enstitü	Güneli
A.Nitrate N/ha	0	7.4	12.7	10.8	9.7	7.1	9.5	10.3	11.1	8.9	10.7 d
	60	14.7	16.6	11.7	16.3	16.7	15.2	18.1	16.6	15.3	16.2 c
	120	20.3	24.5	17.7	24.2	22.6	25.2	22.3	25.6	20.7	24.9 a
	Av..	14.1	18.0	13.4	16.7	15.5	16.6	16.9	17.8	15.0	17.3
A. Nitrate Av.		<i>Enstitü 2002</i>		15.0		<i>Güneli 2002</i>		17.3		LSD (F xR)Güneli4.2*	
Urea	0	7.3	8.4	4.9	12.1	.63	8.9	9.3	12.0	6.9	10.4 d
	60	13.6	15.6	13.6	19.2	17.6	20.0	19.6	26.0	16.1	20.2 bc
	120	15.9	21.5	22.5	22.7	22.9	21.6	19.7	19.7	20.3	21.4ab
	Av.	1,23	1,51	1,37	1,80	1,56	1,68	1,62	1,93	LSD (R)	
Urea Av.		<i>Enstitü 2002</i>		14.4		<i>Güneli 2002</i>		,7.3		<i>Enstitü</i>	<i>Güneli</i>
Time Av..		13.2	16.5	13.5	17.3	15.5	16.7	16.5	18.5	1.87**	2.9**
Rate kg N/ha	0	7.4	10.5	7.8	10.9	6.7	9.2	9.8	11.6	7.9 c	10.5 c
	60	14.1	16.1	12.7	17.7	17.1	17.6	18.8	21.3	15.7 b	18.2 b
	120	18.1	23.0	20.1	23.4	22.8	23.4	21.0	22.7	20.5 a	23.1 a

*significant at 5 % level, **significant at 1 % level, N.S non significant

Table 8.- Effect of N fertilizers, rates and time of application on straw n uptake (kg n/ha)

Research workers like ALCOZ *et al.* (1993), MAHLER *et al.* (1994), GELETO (1994), BOMAN *et al.* (1995) also found out maximum NH_4^+N with increasing rates of N fertilization. However workers like LIOVERS *et al.* (2001), OTTMAN *et al.* (2000a) found an increase of NH_4^+N to some rates and than no significant differences were found by them. Due to leaching losses of Nitrogen in high rain fall areas, ammonium N fertilizers were recommended by KLIMER and WEBB (1968).

Type of Fertilizer	Enstitü location		Av.
	2001	2002	
Ammonium Nitrate	8,14	7,87	8,01
Urea	7,22	8,34	7,78
Time of Application	N.D		
February	8,32	8,07	8,19
March	7,48	6,13	6,80
April	7,46	8,43	7,94
May	7,47	9,83	8,65
Rate kg N7ha)	N.D		
0	6,67 b	5,98 b	6,33
60	8,37 a	9,28 a	8,83
120	8,00 a	9,08 a	8,54
Av.	7,68	8,11	
LSD	1,32**	1,20**	
CV, %	34,24	29,59	

*significant at 5 % level. ** significant at 1 % level. N.S non significant

Table 9.- Effect of N fertilizers, rates and time of application on nh_4^+n content of soil after the harvest of wheat crop

Effect of N fertilizers, rates and time of application on NO₃-N content of the soil after wheat harvest

The soil analysis data regarding the soil nitrate content after harvesting of the crop is given in table 10. As it is seen in table 10, that 7.51, 6.91, 9.67 and 9.24 ppm NO₃-N in the year 2001 and 8.41, 8.34, 11.75 and 12.95 ppm NO₃-N in the year 2002 was obtained at 20th Feb., 20th March, 20th April and 20th May time of application respectively. Late nitrogen application (April and May) has increased the NO₃-N content of the soil.

Enstitü location											
Type of fertilizer	Rate kg N/ha	Application time									
		February		March		April		May		Rate Av.	
		2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
A. Nitrate	0	5,33	5,28	5,58	6,24	7,05	8,02	5,99	7,83	5,99	6,84
	60	7,56	8,07	8,30	8,91	11,7	12,01	11,4	18,64	9,77	11,91
	120	9,94	9,22	8,98	6,58	12,1	17,37	10,2	16,40	10,32	12,39
	Av..	7,61	7,52	7,62	7,24	10,3	12,47	9,24	14,29	8,69	10,38
A. Nitrate Av.		2001		8,69		2002		10,37		2002 LSD (T x R):3,61*	
Üre	0	6,57	7,11	6,04	7,90	5,84	8,25	6,72	5,97	6,29	7,30
	60	7,03	9,03	6,11	10,90	10,9	12,94	8,50	12,07	8,15	11,24
	120	8,65	11,74	6,44	9,50	10,2	11,90	12,5	16,80	9,47	12,49
	Av..	7,42	9,29	6,20	9,43	9,03	11,03	9,24	11,61	LSD (Rate)	
Urea Av.		2001		7,97		2002		10,34		2001	2002
Time Av.		7,51	8,41	6,91	8,34	9,67	11,75	9,24	12,95	1,60**	1,80**
Rate	0	5,95	6,19 e	5,81	7,07de	6,45	8,13 de	6,35	6,89 de	6,13 b	7,07 b
	6	7,29	8,55 de	7,20	9,90cd	11,3	12,48 b	9,98	15,35 ab	8,96 a	11,57 a
	12	9,29	10,4 cd	7,71	8,03de	11,1	14,6 ab	11,39	16,60 a	9,89 a	12,44 a

*significant at 5 % level. **significant at 1 % level. N.S non significant

Table 10.- Effect of N fertilizers, their rates and time of application on NO₃-N content of soil (ppm)

BOMAN *et al.* (1995), have reported in their studies that nitrogen fertilizer application timings have no effect on the profile distribution of NO₃-N and on the residual amount of NO₃-N. Similar results were also obtained by CHRISTENSEN and MEINTS (1982), MEELU *et al.* (1987), GRAVELLE *et al.* (1988). In contrast to this the workers like JANZEN *et al.* (1991) and GELETO *et al.* (1994) have found out that application timings have increased the amount of NO₃-N in soil after harvesting.

4.- Conclusion

Generally N fertilizer rates have increased the biologic yield, chlorophyll content of leaves, sedimentation value of grain and also have increased the protein content of wheat grain. Keeping these characteristics in mind, the application of N fertilizers must be done more than once in spring time, that is early and late spring. Since wheat prices are not fixed on quality basis in Turkey. But in future when prices are fixed on grain quality, then late N fertilizer application must be done to full fill this international requirement.

Acknowledgements

The authors are highly thankful to the authorities of Agriculture Research Institute Eskişehir / Turkey for their full support in conducting and carrying out field experiments and their sincere support for laboratory facilities for Plant and soil analysis and for compilation of the results.

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