Asian Journal of Chemistry Vol. 20, No. 4 (2008), 3069-3078

Requirement and Application Frequencies of Nitrogen Fertilizer on Bread Wheat Variety, Arpathan-9

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The split application of nitrogen required by wheat for seed yield was more advantageous than single application. But the frequencies of nitrogen application is not clear and depends especially on rain and irrigational conditions. On the other hand, nitrogen requirement of a variety varies depending on its genetic yield potential and the environmental conditions. In this study, the effects of increasing amounts of nitrogen and their application frequencies on the seed yield and yield components of a bread wheat variety, Arpathan-9, were investigated under ecological condition of sub-mediterranean climate. The experimental results indicated that increasing amount of nitrogen significantly affected the grain yield of the variety. The highest seed yields were obtained from plots to which 120, 160 and 200 kg N ha^{-1} were applied. Applying the halves of different nitrogen amounts at one or two different times made no significance when seed yield was considered. Seed yield components determined in this study were also significantly affected by nitrogen fertilizer levels in the same way as seed yield. Applying the half of each level of nitrogen fertilizer at one and two time had no effect neither on seed yield nor on seed yield components.

Key Words: Bread wheat, Yield and Yield components, Levels and Application frequencies of Nitrogen fertilizer.

INTRODUCTION

The Marmara region which has a typical sub-mediterranean climate presents favourable conditions for wheat production. It is a desirable aim of the Ministry of Agriculture and Village Affairs and of wheat growers to increase yearly seed production in this region as in some other regions of Turkey. However, there is not enough land for extensive wheat cultivation in the region. Thus, the only way to increase yearly seed production is to increase seed yield per unit area. The fertilization of wheat especially with nitrogen is one of many agronomic practices used to increase seed yield. On this subject, there are limited studies conducted in the Marmara region.

Many researches were conducted to investigate the effects of chemical fertilizers on seed yield of wheat in many regions of the world. Some of these closely related to present study have been summarized as below. Kopetz[1] reported that nitrogen applied at the stages of tillering, elongating and blooming stages increased spike number, seed number/spike and seed weight/spike, respectively.

Kurten[2] reported that 40 % of the total nitrogen has been taken by wheat from germination to the end of tillering, 20 % of it from stem elongation to spike formation and 40 % of it from blooming and seed formation to harvesting times and that early application of nitrogen in spring increased the number of tiller and late application in spring increased seed number/ plant, 1000-seed weight and protein content. Edwald[3], concluded that the application of nitrogen at stem elongation stage has increased the spike number per unit area, the seed number/spike and 1000-seed weight and that the nitrogen application at tillering stage decreased seed number/spike. Christian[4], in an experiment conducted on wheat, applied: (a) the total amount of nitrogen at sowing time, (b) half of it at sowing time and half of it at tillering time, (c) one third of the nitrogen at sowing time, one third at tillering time and one third at stem elongation stage. In this study, seed yield of (a) and (c) treatments was found similar. Nitrogen fertilizer given late was determined to be more advantageous. Aufhammer *et al.*[5] reported that the effect of the application time of nitrogen fertilizer depended on weather conditions, that the application of higher nitrogen amount was advantageous at the beginning of spring growth and that the application of nitrogen at stem elongation time increased seed yield. Yürür and Gençtan[6] stated that the application time of nitrogen to wheat in Marmara region had to be taken carefully chosen, one-third of it should be applied at sowing time and some of the two-third of it during tillering time.

EXPERIMENTAL

A bread wheat cultivar, Arpathan-9, (*T. aestivum* var.aestivum. em.Tell), which is of Hungarian origin, was used as plant material.

Sowing density was 600 seeds/m^2. The experiment was set up by using randomized block experimental design with four replications. The plots were fertilized with a standard dose of 45 kg P_2O_5 ha^{-1} of phosphorous fertilizer. Nitrogen fertilizers were applied at six-different levels (0, 40, 80, 120, 160 and 200 kg N ha^{-1}) and each level at two different times: (a) one-half at sowing + one-half at tillering, (b) one-half at sowing + one-fourth at tillering + one-fourth at stem elongation. The treatments were presented on Table-1.

In the research, seed yield, plant height, spike length, spikelet number/ spike, seed number/spike, seed weight/spike and 1000 seed weight were determined and evaluated.

TABLE-1
LEVELS AND THE APPLICATION FREQUENCIES OF NITROGEN FERTILIZER

Nitrogen	Application frequencies
N_0 (0)*	
N_{40} (2)	One-half sowing + one-half tillering
N_{40} (3)	One-half sowing + one-fourth tillering + one-fourth stem elongation
N_{80} (2)	One-half sowing + one-half tillering
N_{80} (3)	One-half sowing + one-fourth tillering + one-fourth stem elongation
N_{120} (2)	One-half sowing + one-half tillering
N_{120} (3)	One-half sowing + one-fourth tillering + one-fourth stem elongation
N_{160} (2)	One-half sowing + one-half tillering
N_{160} (3)	One-half Sowing + one-fourth tillering + one-fourth stem elongation
N_{200} (2)	One-half sowing + one-half tillering
N_{200} (3)	One-half Sowing + one-fourth tillering + one-fourth stem elongation

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

The analysis of variance was performed on morphological measurements and yield data using MINITAB (University Texas, Austin) and MSTAT-C (Version 2.1 Michigan State University, 1991) programs.

Yield and yield components were statistically analyzed and L.S.D. method was used to determine the significance of means of treatments at 0.01 probability level.

RESULTS AND DISCUSSION

The seed yields obtained from the experiment were presented on Table-2. Each of the nitrogen levels increased the seed yield of wheat in the first year, but had no effect in the second year when they were compared with the unfertilized plots.

In the first year, the highest seed yields were reached on the plots treated with higher nitrogen fertilizer levels (160 and 200 kg N ha^{-1}) applied either two or three times a year. In the second year, rainfall was high and washed nitrogen fertilizer off the soil. Thus, the effects of nitrogen were hidden. The seed yields averaged over two years were significantly affected by nitrogen levels, but not by the number of applications. The highest seed yield (4194 kg ha^{-1}) was obtained when 160 kg N ha^{-1} was applied in three splits a year, half at sowing, one-fourth at tillering and one-fourth at stem elongation stages. As a result, 160 kg N ha^{-1} applied three times a year, produced as much higher seed yield as 47 % than the unfertilized condition.

TABLE-2
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE SEED YIELDS (Kg ha^{-1}) OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	1954.0 e	3738	2846.0 h
N_{40} (2)	2612.0 de	3731	3172.0 g
N_{40} (3)	2271.0 de	4323	3295.0 f
N_{80} (2)	3500.0 bc	3856	3678.0 e
N_{80} (3)	3090.0 cd	4170	3630.0 e
N_{120} (2)	3770.0 abc	4367	4069.0 c
N_{120} (3)	3831.0 abc	3981	3906.0 d
N_{160} (2)	4402.0 a	3709	4056.0 c
N_{160} (3)	4265.0 ab	4124	4194.0 a
N_{200} (2)	4550.0 a	3708	4129.0 b
N_{200} (3)	4572.0 a	3696	4134.0 b
LSD	466.1	–	56.2

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

The results of seed yields associated with nitrogen fertilization in this research were similar to the results of some researches as well as different from those other researchers. For example, the present results were similar to the results of Christian[4], but contrasts with those of previous reports[7,8]. These differences may arise from the different ecological conditions in which different researches were conducted.

Plant height: The variance analyses of plant heights showed that the effects of the nitrogen fertilizer levels had significant, but the frequencies of the applications had no effect on plant heights (Table-3).

As in the seed yield, plant heights were positively affected by nitrogen fertilizer levels in the first year. The plant heights in the first year varied from 55.3 to 84.5 cm, with the lowest plant height on the plots with no nitrogen fertilizer and the highest plant height on the plots fertilized with 200 kg N ha^{-1}.

In second year, neither nitrogen levels nor their application frequencies affected plant heights. On the other hand, when the results of the averages of two-year were concerned, it was seen that the plant heights gathered in three groups, with the lowest plant heights on the plots without fertilizer and the highest on the plots fertilized with 200 kg ha^{-1} N applied at sowing and tillering stages.

The difference between the lowest and the highest plant heights was 16.6 cm. In general, all of the nitrogen fertilizer levels increased the heights of the plants when they were compared with the unfertilized condition, but there were no differences found between them.

TABLE-3
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE PLANT HEIGHTS (cm) OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	55.30 e	62.3	58.80 b
N_{40} (2)	61.50 de	65.0	63.30 ab
N_{40} (3)	57.50 e	68.4	62.90 ab
N_{80} (2)	72.30 bc	64.9	68.60 ab
N_{80} (3)	68.50 cd	65.3	66.90 ab
N_{120} (2)	76.20 abc	66.3	71.20 ab
N_{120} (3)	78.20 ab	66.2	72.20 ab
N_{160} (2)	80.90 a	65.6	73.30 ab
N_{160} (3)	77.90 ab	66.3	72.10 ab
N_{200} (2)	84.50 a	66.3	75.40 a
N_{200} (3)	82.60 a	64.5	73.60 ab
LSD	4.92	–	15.36

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

Another important point was that the plant heights of the first year were higher than those of the second year. This might have been resulted from the different precipitation amounts fallen in different experimental years. The present findings matched with the results of Guzel *et al.*[9].

Spike length: The spike lengths were significantly affected by the nitrogen amounts without effects of application frequencies in the first year. The spike lengths were decreased by N_{40} (2,3) level and increased somewhat by N_{80} (2,3), N_{120} (2,3) and N_{160} (2,3) levels. The effects of N_{200} (2,3) level were more evident and the spikes became longer than those of the other nitrogen treatments including the unfertilized condition. In the second year, neither nitrogen levels nor application frequencies affected the spike lengths (Table-4).

The average spike lengths of two years belonging to the nitrogen levels formed three groups. The application of N_{200} (2) yielded the highest spike length (8.5 cm). The spike lengths of N_{40} (2,3) were somewhat shorter than those of the other treatments. As the nitrogen levels increased from N_{80} to N_{200}, the spike length also increased but at a decreasing rate. These results indicated somewhat resemblance to those of Guzel *et al.*[9].

Spikelet number/spike: The effects of nitrogen levels were found significant on the spikelet numbers in the first year's and on the combined year's values (Table-5).

TABLE-4
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE SPIKE LENGTHS (cm) OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	7.6000 def	7.2	7.400 ab
N_{40} (2)	7.1000 ef	7.3	7.200 b
N_{40} (3)	6.7000 f	7.3	7.000 b
N_{80} (2)	7.8000 cde	7.1	7.500 ab
N_{80} (3)	7.8000 cde	7.4	7.600 ab
N_{120} (2)	8.1000 bcd	7.5	7.800 ab
N_{120} (3)	8.0000 bcd	7.3	7.700 ab
N_{160} (2)	8.5000 abc	7.7	8.100 ab
N_{160} (3)	8.2000 bcd	7.5	7.900 ab
N_{200} (2)	9.3000 a	7.6	8.500 a
N_{200} (3)	8.7000 ab	7.2	8.000 ab
LSD	0.6149	–	1.197

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

TABLE-5
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE SPIKELET NUMBERS PER SPIKE OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	13.800 f	16.7	15.300 ab
N_{40} (2)	13.100 g	16.3	14.700 b
N_{40} (3)	12.300 g	16.9	14.600 b
N_{80} (2)	14.600 def	15.9	15.300 ab
N_{80} (3)	14.400 ef	16.7	15.600 ab
N_{120} (2)	15.400 bcd	17.3	16.400 ab
N_{120} (3)	14.700 cde	17.1	15.900 ab
N_{160} (2)	15.500 bc	17.5	16.500 ab
N_{160} (3)	15.200 bcde	17.0	16.100 ab
N_{200} (2)	17.200 a	17.2	17.200 a
N_{200} (3)	15.600 b	16.8	16.200 ab
LSD	0.840	–	2.419

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

More precipitation in the second year washed most of the nitrogen fertilizer off from the soil and, therefore, the effects of nitrogen were lost and there were no significant effects found.

Seed number/spike: Variance analyses indicate that the effects of nitrogen levels significantly affected the seed numbers in the first year and in the combined years but not in the second year. In the first year, the lowest and the highest seed number/spike appeared on the unfertilized plots and the plots fertilized with N_{200} (2). In general, each level and each application frequency increased seed number/spike when they were compared with the unfertilized conditions.

As in the other components, neither levels nor application frequencies of nitrogen fertilizer had an effect on the seed number/spike in the second year. This result was due to the excessive rainfall in the second year and nitrogen leaching away from the soil.

TABLE-6
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE SEED NUMBER PER SPIKE OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	28.200 e	35.2	31.70 ab
N_{40} (2)	22.600 f	35.4	29.00 a b
N_{40} (3)	21.900 f	35.7	28.80 b
N_{80} (2)	29.700 cde	34.8	32.30 ab
N_{80} (3)	28.700 de	37.7	33.50 ab
N_{120} (2)	31.200 bc	37.1	34.20 ab
N_{120} (3)	32.400 b	35.6	34.00 ab
N_{160} (2)	30.700 bcd	35.1	32.90 ab
N_{160} (3)	31.200 bc	37.6	34.40 ab
N_{200} (2)	36.600 a	38.0	37.30 a
N_{200} (3)	32.800 b	31.6	32.20 ab
LSD	4.896	–	6.99

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

The values of seed number/spike averaged over 2 years indicated significant differences in respect of nitrogen fertilizer effects. N_{200} (2) yielded the highest and N_{40} (2,3) yielded the lowest values of seed number/spike. There are similar findings in the reference sources, for example, Hobss[10] determined that increasing nitrogen amounts increased seed yields and these increases resulted from the seed number increase per spike. Some researchers reported that nitrogen applied at stem elongation stage increased seed number per spike (1,3).

Seed weight/spike: In the variance analyses of seed weight/spike, it was determined that in the first year and in the combined years, nitrogen levels had a significant effect (Table-7) and there were differences between the effects of the nitrogen levels on seed weight per spike.

TABLE-7
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE SEED WEIGHTS (g) PER SPIKE OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	0.960 bcd	1.38	1.170 ab
N_{40} (2)	0.930 cd	1.21	1.070 b
N_{40} (3)	0.770 d	1.36	1.070 b
N_{80} (2)	1.130 abc	1.29	1.200 ab
N_{80} (3)	1.050 bc	1.54	1.300 ab
N_{120} (2)	1.090 abc	1.51	1.300 ab
N_{120} (3)	1.170 ab	1.29	1.230 ab
N_{160} (2)	1.070 bc	1.31	1.190 ab
N_{160} (3)	1.080 bc	1.43	1.260 ab
N_{200} (2)	1.300 a	1.42	1.360 a
N_{200} (3)	1.100 abc	1.15	1.130 ab
LSD	0.213	–	0.274

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

The plots treated with the N_{200} (2) and N_{40} (3) produced the highest and the lowest seed weight/spike values, respectively.

No effects of nitrogen fertilizer levels and application frequencies were found on seed weight/spike in the second year. The nitrogen was washed away from soil due to the heavy rainfall in the second year. This situation might have caused the effects of nitrogen fertilizer levels to disappear as stated before. It was reported by Aufhammer *et al.*[5] that the increasing nitrogen levels affect seed weight per spike.

1000-Seed weight: 1000-Seed weight of the variety was affected by the amounts of nitrogen fertilizer amounts both in the first and in the second experimental year according to the variance analyses. The application of the nitrogen fertilizer two or three times a year did not have different effects on 1000-seed weight in either year. The relation of effects of nitrogen levels to 1000-seed weight was regular in the first year but irregular in the second year. In general, all of the nitrogen levels produced 1000-seed weights higher than the non-fertilization condition in the first year. However, there were no differences between N_{80}, N_{120}, N_{160} and N_{200} in this respect and they produced seeds which had higher 1000-seed weight than that of N_{40} application. In the second year, there were irregular relations between nitrogen applications and 1000-seed weights. In this, 1000-seed weight generally decreased whenever nitrogen doses were applied. The more precipitation fell in the second year might have caused nitrogen fertilizer to increase the vegetative growth, in return, to decrease the 1000-seed weight.

TABLE-8
EFFECTS OF NITROGEN FERTILIZER LEVELS AND APPLICATION FREQUENCIES ON THE 1000-SEED WEIGHTS (g) OF BREAD WHEAT VARIETY, ARPATHAN-9

Nitrogen	Years		Two-year average
	1988	1989	
N_0 (0)*	34.600 d	38.1	36.400 abc
N_{40} (2)	36.700 bc	34.8	35.800 c
N_{40} (3)	36.100 cd	35.6	35.900 bc
N_{80} (2)	38.000 ab	36.8	37.400 abc
N_{80} (3)	37.800 abc	39.2	38.500 a
N_{120} (2)	38.900 a	35.5	38.000 abc
N_{120} (3)	39.200 a	35.1	37.200 abc
N_{160} (2)	39.300 a	34.2	36.800 abc
N_{160} (3)	39.400 a	36.7	38.100 ab
N_{200} (2)	38.600 ab	33.6	36.100 bc
N_{200} (3)	39.400 a	34.0	36.700 abc
LSD	1.011	–	2.258

*Numbers in brackets indicate the application numbers of nitrogen levels.
**Sub numbers of N indicate the levels of nitrogen fertilizer applied per hectare.

In two-year average, the trend of the effects of nitrogen applications was not clear. Some of the applications such as N_{40} (2) decreased and some of them such as N_{80} (3) increased 1000-seed weight when they were compared with the unfertilized condition.

There were some contradictions in the references reviewed. For instance, some researchers[5,11,12] reported that increasing amounts of nitrogen and late applications increased 1000-seed weight but some of them reported opposite results[13].

Conclusion

This research was conducted to determine the nitrogen requirement of a bread wheat variety, Arpathan-9 and to determine the application frequency or time of nitrogen in the ecological condition of the Marmara region.

In this research conducted for two years, nitrogen levels but not frequencies of applications significantly affected the seed yield and the yield components in the first year. In general, the applications of N_{160} and N_{200} produced higher seed yields than the other nitrogen levels. However, there were no significant differences found between these two levels. Thus, due to the economical considerations, only N_{160} may be proposed to be applied half at sowing and half at tillering time.

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(*Received*: 13 August 2007; *Accepted*: 16 January 2008) AJC-6216