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Effect of Different Doses of Nitrogen Fertilizer on Yield and Yield Concentration of Two-Rowed Barley Cultivars¶

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The research was conducted in the experimental field of Department of Field Crops, Faculty of Agriculture, Uludag University, Bursa, Turkey. Totally ten cultivars were examined for two years (Angora, Caminant, Goldie, Viva, Jubilant, Compact, Orbit, Kaya, Sladoran and Balkan-96). The experiment area was established in a randomized design with three replicates having 500 spikes m^{-2} on 1.2 × 5 m = 6 m^2. Pure nitrogen dose (33 % $NH_4NO_3^-$) was applied 0 kg N da^{-1} (N_0), 5 kg N da^{-1} (N_5), 10 kg N da^{-1} (N_{10}), 15 kg N da^{-1} (N_{15}) and 20 kg N da^{-1} (N_{20}) to each cultivar. It was found that grain number per spike and yield of cultivars increased until N_{10}, 1000-grain weight of the cultivars increased until N_{15} application but following the application of N_{20}, there was a decrease in the above-mentioned characteristics. However, increasing nitrogen doses increased plant heights up to N_{20} doses including N_{20} but it was observed that plant logging occurred in some cultivar. It was determined that there was a negative correlation between yield and plant height and a positive correlation between yield and grain number per spike.

Key Words: Barley, Nitrogen fertilizer, Plant height, 1000 Grain weight.

INTRODUCTION

Barley, in general, is cultivated mainly for two purposes to be used as forage and in maltbeer production. To increase the production and the yield of barley, determination of the appropriate agronomic techniques is also significant besides having the cultivars adjusted to the ecological conditions of regions or breeding them.

Fertilization is really important for barley as well as for all culture plants. Especially nitrogen fertilizers are of much more significance on the yield of barley and more quality than the other plant nutrition elements. 30 to 80 % of nitrogen amount applied to soil lose due to various causes[1].

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In order to recover this, 28 to 46.5 % nitrogen application should be done. Thus, a great deal of researches studying the effect of nitrogen fertilizer on the yield and quality of barley are available. The optimum nitrogen dose changes depending upon the ecological conditions of regions. While many researchers report that the application of nitrogen fertilizer to barley increases the yield[2-4] the dose of yield increase is 25 % according to Papastlianov[5], 8-32 % to Deloque *et al.*[6], 4-11 % , to Gouis *et al.*[7] and 30 % to Matinez *et al.*[8], respectively. Yet, the opposite results were also obtained. Conry[9] found grain yield doesn't always increase with the application of nitrogen fertilizer.

Although the results obtained mostly indicate that nitrogen fertilizer increases the yield, there is a limitation for that increase. The studies showed that after an optimum point is reached, increasing nitrogen fertilizer causes damage in plants rather than advantage. Especially the increase in nitrogen doses leads to in plant height and results in lodging and as a result, loss in yield is observed[5]. The most efficient nitrogen dose for yield must be according to Kernich and Halloran[10], 8 kg N da^{-1} to Delogue *et al.*[6], 12 ± 06 kg N da^{-1} to Abeledo *et al.*[11], 14 kg N da^{-1} to McKenze *et al.*[12], 9 kg N da^{-1} to Alam *et al.*[13], respectively.

To determine the yield of barley, as in other cereal genera, the number of spikes per m^2, grain number per spike and 1000-grain weight is the most important components. Begum[14], Begum *et al.*[15] and Geweifel[16] reported that there is a significant and positive relation between the grain number per spike and the grain yield.

Le Gavishi *et al.*[7] explained nitrogen fertilizer applied to barley increases the grain number per spike and 1000-grain weight. El-Hennawy[17] reported 1000-grain weight and grain number per spike is effective on yield. Baethgen *et al.*[18] found the number of grain number per spike could be 30-100 % with an appropriate nitrogen fertilizer. Kernich *et al.*[10] reported that the yield and the number of spike in barley obtained per area increase with the application of nitrogen fertilizer and that nitrogen fertilization encourages tillering.

This study was done to determine the most effective nitrogen doses that will contribute the yield of some two- row barley cultivars, the adaptation trial of which were done in south Marmara region.

EXPERIMENTAL

Totally ten cultivars, seven of which (Angora, Caminat, Goldie, Viva, Jubilant, Compact, Orbit) were obtained from Anatolian Food and Malt Industry (EFES PIRSEN) and three of which (Kaya, Sladoran and Balkan-96) were obtained from Trakya Agricultural Research Institute, were examined for two years.

The experiment area was established in a randomised design with three replicates having 500 spikes per m^2 on 1.2 × 5 m = 6 m^2. Pure nitrogen dose (33 % $NH_4NO_3^-$) was applied 0 kg N da^{-1} (N_0), 5 kg N da^{-1}(N_5), 10 kg N da^{-1} (N_{10}), 15 kg N da^{-1} (N_{15}) and 20 kg N da^{-1} (N_{20}) to each cultivar and half of these amounts was applied to soil on the sowing date as ammonium sulphate and the rest at the end of winter as ammonium nitrate fertilizer. Treatments against weed were performed by hand.

Statistical calculations were performed according to ANOVA analysis. The average values were subjected to F-test at the importance level of 5 and 1 %.

RESULTS AND DISCUSSION

Plant height values of the cultivars were given in Table-1. The doses of ammonium nitrate fertilizer indicated a difference in plant height among cultivars in both years and both the impact of ammonium nitrate doses and of cultivar × dose interaction were found to be 1 % significant.

In present research, it was found that the longest plant height appeared in both Balkan-96 (97.87 and 99.14 cm) and Kaya (96.60 and 98.11 cm) recommended to farmers as standart cultivars for south Marmara region. It was seen that increasing ammonium nitrate doses elongated plant height and was determined that it was N_{20} that supplied the longest plant height. The highest cultivar × dose interaction in both years was found to be Balkan-96 × N_{20}. It was reported that increased ammonium nitrate fertilization in barley also elongated plant height[19,20].

Although two-row barleys are generally preferred to produce malt, they are also grown for forage in some regions. For such purposes, N_{20} doses in Balkan-96, Kaya and Sladoran cultivars may be suggested.

Grain number per spike: The values of grain number per spike were given in Table-2. The doses of fertilizer indicated a difference in grain number per spike among cultivars in both years and these differences were considered 1 % statistically significant. The response of applied ammonium nitrate doses on grain number per spike was found to be 5 % important in first year and 1 % important in second year. The response on cultivars × dose was 5 % important in both years.

As a result of the observations carried out considering the statistical classifications as well, it was determined that the cultivar having the most grain number per spike was Caminant (25.52 grain number per spike) and Goldie (24.27 grain number per spike) in first year. The most effective dose increasing the grain number was N_{10}, the highest combination of cultivar × dose interaction was Caminant × N_{10} and Goldie × N_{10} in first year.

TABLE-1
EFFECT OF DIFFERENT DOSES OF N-FERTILIZER APPLIED IN TWO YEARS ON PLANT HEIGHT OF SOME TWO-ROWED BARLEY CULTIVARS

Cultivars	Years	Doses (kg da^{-1})					Average of cultivars (cm)
		0	5	10	15	20	
Angora	1	61.50z[‡	68.30u-x‡	72.73s-v‡	80.50no‡	95.10f-I‡	75.62e‡
	2	63.20pq‡	67.40n-q‡	72.73klm‡	87.77h‡	99.77a-d‡	78.17c‡
Sladoran	1	78.20n-o‡	85.70lm‡	96.07e-h‡	93.60hij‡	100.10cde‡	90.53c‡
	2	76.13ijk‡	95.60c-g‡	96.07c-f‡	98.10b-e‡	99.30b-e‡	93.04b‡
Caminant	1	74.00q-t‡	90.60ijk‡	96.77e-h‡	99.70def‡	104.80abc‡	93.17b‡
	2	77.83jkl‡	95.27d-g‡	96.77c-f‡	96.33c-f‡	96.60c-f‡	92.56b‡
Goldie	1	63.20yz‡	73.40rst‡	72.93stu‡	78.10n-r‡	82.50mn‡	74.02e‡
	2	64.73opq‡	67.00n-q‡	72.93klm‡	72.43k-n‡	77.13ijk‡	70.84d‡
Jubilant	1	56.70\]‡	64.10xyz‡	64.33xyz‡	69.50t-w‡	73.10st‡	65.54g‡
	2	54.30r‡	62.43q‡	64.33opq‡	68.33m-p‡	72.53klm‡	63.58f‡
Compact	1	60.40z[\‡	66.30wxy‡	68.00vwx‡	75.30p-s‡	79.40nop‡	69.88f‡
	2	64.50opq‡	64.80opq‡	68.00m-p‡	74.07jkl‡	78.60ij‡	69.99de‡
Orbit	1	55.50[‡	64.20xyz‡	69.30t-w‡	76.40o-s‡	79.10nop‡	68.90f‡
	2	52.97r‡	66.93n-q‡	69.30l-o‡	74.30jkl‡	75.83ijk‡	67.86e‡
Kaya	1	86.47klm‡	95.10f-i‡	98.90d-g‡	103.10bcd‡	107.00ab‡	98.11a‡
	2	89.40h‡	92.37fgh‡	98.90b-e‡	100.20abc‡	102.17ab‡	96.60a‡
Viva	1	58.30[\]‡	69.50t-w‡	80.67no‡	88.30kl‡	94.60g-j‡	78.27d‡
	2	56.90r‡	78.73ij‡	80.67i‡	90.60gh‡	94.67efg‡	80.31c‡
Balkan-96	1	90.10jkl‡	96.70e-h‡	96.03e-h‡	103.40bcd‡	109.50a‡	99.14a‡
	2	92.07fgh‡	94.87d-g‡	96.03c-f‡	102.30ab‡	104.10a‡	97.87a‡
Average of doses (cm)	1	68.53e‡	77.39d‡	81.57c‡	86.79b‡	92.52a‡	–
	2	68.80e‡	78.54d‡	81.57c‡	86.44b‡	90.07a‡	–

†$p < 0.05$; ‡$p < 0.01$.

As seen in Table-2, it is true that application of nitrogen fertilizer increases the grain number per spike. This result is similar to what many researchers have reported[7,10,17,18]. It was found that grain per spike of the cultivars increased until N_{10} application but following the application of N_{20}, there was a decrease in the above-mentioned characteristics. This may be due to vegetative development of nitrogen doses in the plant as a result generative development reduced.

1000-Grain weight: 1000-Grain weight of cultivars was given in Table-3. The doses of fertilizer indicated a difference in yield among cultivars in both years and these differences were seen 1 % statistically important. The response of applied nitrogen doses on cultivar × dose interaction was found to be 5% important in first year and second year it was found to be 1 % important.

TABLE-2
EFFECT OF DIFFERENT DOSES OF N-FERTILIZER APPLIED IN TWO YEARS ON GRAIN NUMBER PER SPIKE OF SOME TWO-ROWED BARLEY CULTIVARS

Cultivars	Years	Doses (kg da^{-1})					Average of cultivars (no.)
		0	5	10	15	20	
Angora	1	20.80e-l†	21.20d-k†	24.20bcd†	22.53c-h†	22.2c-j†	22.19bc‡
	2	18.10lm†	21.88f-j†	22.65e-j†	22.50e-j†	21.15h-l†	21.26c‡
Sladoran	1	20.15i-m†	22.73d-j†	23.92a-h†	23.10b-j†	22.36e-j†	22.45bc‡
	2	19.23f-m†	20.00g-m†	21.96c-j†	21.50c-k†	20.73e-m†	20.69d‡
Caminant	1	23.03i-m†	23.97b-e†	29.47a†	26.57ab†	24.56bc†	25.52a‡
	2	20.10jm†	21.70f-j†	26.15ab†	25.20a-e†	24.12a-h†	23.45ab‡
Goldie	1	22.16ej†	22.83c-j†	26.93a†	24.73a-f†	24.71a-f†	24.27a‡
	2	21.19hk†	23.62b-h†	25.10a-e†	24.50a-g†	22.60e-j†	23.40ab‡
Jubilant	1	20.53n†	22.30c-i†	23.97b-e†	22.73c-g†	22.80c-g†	22.47b‡
	2	18.10lm†	20.17i-m†	24.17a-h†	23.88a-h†	23.80b-h†	22.02c‡
Compact	1	21.13c-g†	21.97c-j†	23.50d-f†	22.73c-g†	22.27c-j†	22.32b‡
	2	17.28m†	21.63g-j†	23.70b-h†	22.83c-j†	22.16e-j†	21.52c‡
Orbit	1	21.40c-k†	21.90c-j†	22.00c-j†	21.50c-k†	21.83c-k†	21.73bcd‡
	2	18.17lm†	22.81c-j†	24.73a-f†	23.66b-h†	23.18b-i†	22.51bc‡
Kaya	1	20.43j-n†	20.93e-l†	21.70c-k†	21.53c-k†	21.90c-j†	21.30bcd‡
	2	20.24i-m†	21.16h-l†	23.83b-h†	23.41b-h†	22.14e-j†	22.16bc‡
Viva	1	19.03c-k†	19.43h-m†	23.03c-g†	20.90e-l†	21.80c-k†	20.89cd‡
	2	21.83f-j†	23.19b-I†	25.81abc†	25.74a-d†	23.70b-h†	24.05a‡
Balkan-96	1	17.53f-m†	18.67k-n†	19.20i-m†	19.03j-n†	19.23i-m†	18.73e‡
	2	15.97mn†	17.80mn†	20.33f-m†	19.80g-m†	20.16g-m†	18.81e‡
Average of doses (no.)	1	20.64d†	21.59cd†	23.79a†	22.53bc†	22.36ab†	–
	2	19.04d‡	21.39c‡	23.84a‡	23.30ab‡	22.37bc‡	–

†$p < 0.05$; ‡$p < 0.01$.

As a result of the observations carried out considering the statistical classifications as well, it was determined that the cultivars having the most 1000-grain weight were Goldie (47.40 g) and Caminant (47.24 g) in second year. The most effective increasing in nitrogen dose was N_{15}, the highest combination of cultivar x dose interaction were Compact × N_{15} and Caminant × N_{15} in first year.

As seen in Table-3, the application of ammonium nitrate fertilizer increased 1000-grain weight. As in grain number per spike, 1000-grain weight of cultivars increased till the application of N_{15} but after this dose increasing doses decreased 1000-grain weight. We may point out as doses affecting 1000-grain weight, we observed that N_{10} and N_{15} were of significance.

Yield: Yield values of the cultivars were given in Table-4. The doses of ammonium nitrate fertilizer indicated a difference in yield among cultivars in both years and both the impact of nitrogen doses and of cultivar × dose interaction were found to be 1 % significant.

TABLE-3
EFFECT OF DIFFERENT DOSES OF N-FERTILIZER APPLIED IN TWO YEARS ON 1000-GRAIN WEIGHT OF SOME TWO-ROWED BARLEY CULTIVARS

Cultivars	Years	Doses (kg da^{-1})					Average of cultivars (g)
		0	5	10	15	20	
Angora	1	40.38l-r†	42.60g-q†	43.82e-n†	42.5h-q†	43.89e-m†	42.63c‡
	2	44.30i-m†	45.41fgh†	48.10bcd†	48.50bc†	46.00ef†	46.47abc‡
Sladoran	1	45.28f-i†	44.00j-n†	43.08n-s†	45.53fgh†	42.63q-t†	44.06bc‡
	2	41.00u†	43.60l-q†	47.00de†	45.18f-i†	44.51h-l†	44.25bcd‡
Caminant	1	44.58h-l†	45.10f-j†	45.00f-j†	49.8a†	45.74fg†	46.04ab‡
	2	38.10d-m†	49.90ab†	49.80abc†	49.16ab†	49.28a-d†	47.24a‡
Goldie	1	43.16f-p†	45.80a-k†	43.22f-p†	44.70c-m†	41.68i-r†	43.71c‡
	2	49.00ab†	47.58cd†	47.43cd†	47.16d†	45.83fg†	47.40a‡
Jubilant	1	36.69r†	38.42o-r†	39.66m-r†	38.71n-r†	37.54qr†	38.20d‡
	2	32.93y†	38.50wx†	39.78v†	39.45vw†	37.50x†	38.63e‡
Compact	1	44.47d-m†	47.09a-h†	47.32a-h†	50.78a†	44.60d-m†	46.85a‡
	2	44.21d-m†	46.34a-j†	47.75a-g†	48.25a-f†	46.73a-i†	46.65ab‡
Orbit	1	38.52o-r†	36.74r†	44.93b-l†	46.55a-i†	45.49b-l†	42.44c‡
	2	42.37h-q†	41.28j-r†	43.20f-p†	44.75b-m†	46.38a-j†	43.59cd‡
Kaya	1	41.60tu†	42.10stu†	42.86o-s†	48.80ab†	45.70fg†	44.21bc‡
	2	43.86k-o†	43.00n-s†	42.48rst†	42.74p-s†	42.66p-t†	42.95d‡
Viva	1	42.37h-q†	45.28b-l†	44.88b-l†	44.78b-m†	44.66c-m†	44.39bc‡
	2	44.83g-k†	45.26f-I†	43.76k-p†	45.00f-j†	45.56fgh†	44.88a-d‡
Balkan-96	1	39.67m-r†	41.17k-r†	43.46e-o†	44.29d-m†	48.61a-e†	43.44c‡
	2	43.00n-s†	43.25m-r†	47.35d†	47.12a-h†	43.15n-s†	44.77a-d‡
Average of doses (g)	1	40.99c†	43.46b†	44.80ab†	45.30a†	44.88ab†	–
	2	43.43d‡	43.78c‡	44.69b‡	45.73a‡	43.93c‡	–

†$p < 0.05$; ‡$p < 0.01$.

As seen in Table-4, as a consequence of observations carried out considering the statistical classifications as well, the cultivar having the highest yield in second year was determined as Viva (555 kg da^{-1}, 576 kg da^{-1}), which was followed by Goldie (518.6 kg da^{-1}, 569.2 kg da^{-1}) in both first year and second year. But while it realized in such conditions in general average, Compact × N_{10} and Goldie × N_{10} were observed in all years.

The highest combinations of cultivar × dose interaction were in N_{10}. It is clearly seen that ammonium nitrate fertilization increases the yield. The response of Caminant, Goldie, Jubilant, Compakt and Viva to nitrogen fertilizer was best between N_0 and N_5 doses and while the yield difference was in 132 kg da^{-1} between 246 kg da^{-1}, Angora, Sladoran and Kaya responded to nitrogen fertilizer best between N_5-N_{10}. The yield difference between N_0 and the optimum point N_{10} was between 238 kg da^{-1} and 243 kg da^{-1} in average doses. The equivalents of these increases per hectare were really satisfying. A lot of researches have reported that nitrogen fertilizer applied

TABLE-4
EFFECT OF DIFFERENT DOSES OF N-FERTILIZER APPLIED IN TWO YEARS ON YIELD OF SOME TWO-ROWED BARLEY CULTIVARS

Cultivars	Years	Doses (kg da^{-1})					Average of cultivars (kg da^{-1})
		0	5	10	15	20	
Angora	1	308.30or‡	319.40pqr‡	529.00hij‡	457.13kl‡	502.00jk‡	423.17d‡
	2	315.00pq‡	335.00n-q‡	538.00fgh‡	465.00i-j‡	500.00hij‡	430.60d‡
Sladoran	1	253.30st‡	301.00qrs‡	416.00lm‡	397.00mn‡	306.00qr‡	334.66e‡
	2	259.00rs‡	315.00pq‡	453.00ijk‡	400.00klm‡	320.00opq‡	349.40e‡
Caminant	1	395.00mn‡	527.77hij‡	544.41g-j‡	548.57g-j‡	524.43hij‡	507.60c‡
	2	390.00lmn‡	540.00e-h‡	586.00c-f‡	573.00d-g‡	524.00gh‡	522.60c‡
Goldie	1	340.00opq‡	586.30d-g‡	671.00a‡	590.20d-g‡	606.00cde‡	518.60a‡
	2	351.0m-q‡	595.00b-e‡	675.00a‡	610.00bcd‡	615.00bcd‡	569.20a‡
Jubilant	1	380.20mno‡	555.17f-i‡	622.00bcd‡	602.00c-f‡	589.13d-g‡	549.70ab‡
	2	390.00lmn‡	548.00e-h‡	637.00abc‡	615.00bcd‡	550.00e-h‡	548.00ab‡
Compact	1	366.53m-p‡	541.63g-j‡	680.00a‡	591.00d-g‡	558.30e-i‡	547.60ab‡
	2	380.00lmn‡	550.00e-h‡	688.00a‡	593.00b-f‡	580.00def‡	558.20ab‡
Orbit	1	359.77nop‡	513.03ij‡	665.00ab‡	549.00g-j‡	551.00g-j‡	527.60b‡
	2	365.00l-p‡	524.00gh‡	645.00ab‡	565.00d-g‡	568.00d-g‡	533.40bc‡
Kaya	1	205.00t‡	290.00rs‡	391.00mn‡	376.00mno‡	361.00nop‡	324.60e‡
	2	220.00s‡	300.00qr‡	410.00jkl‡	390.00lmn‡	375.00l-o‡	339.00ef‡
Viva	1	347.27n-q‡	583.27d-g‡	651.37abc‡	627.20bcd‡	566.73e-h‡	555.00a‡
	2	360.00l-p‡	590.00b-f‡	669.00ab‡	645.00ab‡	586.00c-f‡	576.00a‡
Balkan-96	1	230.00t‡	286.00rs‡	391.00mn‡	341.00opq‡	320.00pqr‡	313.60e‡
	2	250.00rs‡	300.00qr‡	387.00lmn‡	368.lp‡	315.00pq‡	324.00f‡
Average of doses (kg da^{-1})	1	318.60e‡	430.20d‡	556.00a‡	507.80b‡	488.40c‡	–
	2	328.00e‡	459.70d‡	571.80hij‡	522.40b‡	493.30c‡	–

†$p < 0.05$; ‡$p < 0.01$.

to barley increases yield[2-8] but there is a limitation for that increase. Because researches indicated that after a certain optimum point is reached, increasing nitrogen fertilizer causes damage. In our study, it is considered that ammonium nitrate fertilizer applied above N_{10} for some cultivars and N_{15} for some others affect barley yield negatively. Hence it could be said that these are the most effective doses though they change from one cultivar to the other. These results are consistent with the findings of some researchers[10-12]. Whereas, they are consistent with the results of some researchers[6].

In Table-5, correlation values in inspected component were shown. It was determined that there was a negative relationship between plant height and yield but a positive one between grain number per spike and yield. While these results were consistent with those of some researchers[13,21-25]. They are not with others[26,27]. It was reported by most researchers that there is a positive relationship between 1000-grain weight and yield[17,21-25,28]. In present research, it was observed that during first and second year there was a positive relationship between 1000-grain weight and yield.

TABLE-5
CORRELATION VALUES IN INSPECTED COMPONENT

	Doses		Plant height		Grain number per spike		1000-Grain weight	
Years→	1	2	1	2	1	2	1	2
Plant height	0.476‡	0.539‡						
Grain number per spike	0.329†	0.492†	0.442	0.362				
1000-Grain weight	0.309†	0.073‡	0.396	0.107	0.079‡	0.034‡		
Yield	0.470‡	0.466‡	-0.215†	-0.174†	0.104‡	0.411‡	0.156	0.145

†$p < 0.05$; ‡$p < 0.01$.

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