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INFLUENCE OF DIFFERENT NITROGEN LEVELS ON YIELD, AGRONOMIC CHARACTERS AND QUALITY OF MALTING BARLEY*

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Abstract: This study was conducted to determine the effect of nitrogen on agronomic characters, yield and quality parameters at two malting barley cultivars suitable for Meander Valley ecological conditions, in 2003-2004. Four nitrogen levels (40, 80, 120 and 160 kg ha^{-1}) and control were used. Nitrogen fertilizers were applied at two times as pre-planting and tillering stage. A field experiment was arranged as a split plot block design with three replications. The plant height, flag leaf area, yield, thousand kernel weight, test weight, protein content were measured characters. It was obtained that Serife Hanim had higher yield and malting quality than Kaya in the region and 100-112 kg ha^{-1} nitrogen level was sufficient to get reasonable yield and best quality.
Key words: Barley, yield, yield components, quality, nitrogen fertilization, malting barley.

Biralık Arpada Farklı Azot Dozlarının Verim, Tarımsal Özellikler ve Kalite Üzerine Etkisi

Bu çalışma, Büyük Menderes havzasına uygun iki biralık arpa çeşidinde azotun verim, tarımsal özellikler ve kalite üzerine etkisini belirlemek amacıyla 2003-2004 yetiştirme periyodunda yürütülmüştür. Dört farklı azot dozu (40, 80, 120 ve 160 kg ha) ve kontrol kullanılmıştır. Azotlu gübreleme ekim öncesi ve kardeşlenme olmak üzere iki farklı dönemde uygulandı. Deneme 3 yinelemeli olarak Bölünmüş Parseller Deneme Deseninde yürütüldü. Bitki boyu, bayrak yaprağı alanı, verim, bin tane ağırlığı, hektolitre ağırlığı ve protein içeriği incelendi. Şerife Hanım çeşidinin malt kalitesi ve verim yönünden Kaya çeşidinden daha iyi özelliklere sahip olduğu ve 100112 kg/ha azot dozunun en iyi sonucu verdiği saptandı.
Anahtar Kelimeler: Biralık arpa, verim, verim komponentleri, kalite, azotlu gübreleme.

INTRODUCTION

Barley has been grown as a second important cereal crop after wheat in Turkey. Barley (*Hordeum vulgare* L.) is widely used as food and feed, but its most economically important use is for malting. Barley planting area, production and average yield in Turkey were 3.6 million ha. ,9 million ton and 2500 kg ha^{-1}, respectively in 2005. Barley production and planting area in Aegean Region accounts for 8 %, and 7 % of Turkey total, respectively. Environmental conditions and agricultural practices affect the agronomical characters, yield and quality parameters of malting barley. The effects of fertilization especially nitrogen on malting barley is significant. Petrie et al. (2003) investigated the effects of different nitrogen levels on malting barley and, they found that plant height, test weight and 1000 kernel weight were declined as nitrogen levels were increased.

While nitrogen and phosphorus are main nutrients, potassium, sulfur, and other micro nutrients also contribute to increased yields (Harapiak et al., 2000). Abledo et al. (2003) were used four two-rowed malting barley and four different nitrogen dozes (0, 50, 110, and 160 kg ha^{-1}) in Argentina. All cultivars were showed that when the nitrogen level was increased, yield and flag leaf area were increased too.

Well-fertilized barley fields subject to moisture stress will result in grain samples that area higher in protein (< 12.5 to 13.0 % accepted for malt) and have reduced kernel (> 70 to 80% plump required for malt). Nitrogen fertilizer additions have been shown to increase barley yield and protein content, and to depress kernel .

Increasing plant-available water increases yield and , while decreasing protein. The effect of grain protein content on malting quality were found to be significant. (Weston et al., 1993; Eagles et al., 1995). In general, higher available nitrogen in soil (Varvel and Severson, 1987; Weston et al., 1993; Eagles et al., 1995), and abiotic stresses including drought (Morgan and Riggs, 1981; Coles et al., 1991; Grant et al., 1991; Birch and Long, 1990) or heat, in particular combination with water stress (Macnicol et al., 1993; Savin and Nicolas, 1996) may increase barley protein content. A grain protein content of 10.5-11.4 % for malting barley is a standard in the malting industry (Birch and Long, 1990). It is often difficult to keep protein content below the upper limit (11.5%), because protein synthesis is variable over the environmental conditions and cultural practises (Smith, 1990). Barley suitable for malting should have low grain protein content, as high protein content will not only reduce malt extract, but also deteriorate final beer quality (Eagles et al., 1995; Molina-Cano et al., 1997). Protein levels can be too low (inadequate enzymes) and too high (inadequate extract; excessive enzymes and soluble protein) (Anonymous, 2005).

In this study, it was aimed that the effect of different nitrogen fertilizer levels on yield, agronomical characters and quality of two malting barley cultivars in Aydin of Turkey in 2003-2004.

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MATERIALS AND METHODS

This experiment was conducted in the experiment fields of the Field Crops Department of Faculty of Agriculture at Adnan Menderes University in 2003-2004 growing period. A field experiment was conducted as a split plot block design with three replications.

The cultivars used in the experiment were Serife Hanim and Kaya. These are the most used cultivars in Aegean Region. The planting area of Kaya and Serife Hanim cultivars account for 15-20 % of Aegean Region total barley sowing area. Kaya and Serife Hanim are the two-rowed, awned, white seeded and resistance to lodging.

The planting were done in November 21. The plots were 9 m length and consisted of six each row. Four nitrogen levels (40, 80, 120, 160 kg ha $^{-1}$) and control were used and, nitrogen fertilizers were applied at two times. The first half of the nitrogen was applied before planting as a Ammonium sulfate (21 %), the other half at tillering stage as a Ammonium nitrate (33 %). Prior to planting 70 kg ha $^{-1}$ phosphorus an potassium were applied as a TSP (42-44 % P_2O_5), and as a Potassium sulfate (50 % K_2O), respectively. The harvest date of cultivars were May 5 2004. The center four rows of each plot were harvested. The harvested area was 268.8 m^2. The agronomic characters; plant height (cm), flag leaf area (cm^2), yield (kg ha^{-1}) and 1000 kernel weight (g) were observed characteristics. The quality parameters test weight (kg) and protein (%) were investigated. Malt quality determinations were made at the Tuborg A.Ş., Izmir.

RESULTS AND DISCUSSION

Results from the analysis of variance for observed characters were presented in Table 1. The differences among nitrogen levels were found significant for all characters while the cultivar x fertilizer interactions were significant for 1000 kernel weight. It is found that the differences between Kaya and Serife Hanim were significant for test weight values.

The mean values of observed characters were given in Table 2. The lowest plant height values for two cultivars were obtained from control plots. The values of plant height were ranged from 88.3 cm to 119.3 cm for Kaya and from 84.7 cm to 112.7 cm for Serife Hanim. While Kaya had the highest value with the nitrogen application of 160 kg ha $^{-1}$, Serife hanim had the highest plant height with the nitrogen application of 120 kg ha $^{-1}$. Data analysis showed that

Table 1. Variance Analysis of Observed Characters.

Source of Variance	DF	Plant Height	Flag leaf area	Yield	1000 kernel weight	Test weight	Protein
Block	2	21.76	1.20	324.15	1.84	0.28	1.57
Cultivar (A)	1	64.53	2.88	7837.37	154.72	6.52*	0.43
Error 1	2	22.08	0.96	562.38	9.30	0.15	0.47
Fertilizer (B)	4	724.39**	176.96**	52321.72**	31.20**	13.68**	4.95*
A x B	4	11.08	2.23	266.78	15.35*	0.49	0.13
Error 2	16	15.28	0.98	201.46	5.03	0.41	1.43
Total	29	115.13	25.51	7671.24	14.99	2.43	1.71

*, **; significant at probability level 0.05 and 0.01, respectively.

Table 2. The Mean Values of Observed Characters.

Cultivars	Nitrogen Level (kg ha^{-1})	Plant Height (cm)	Flag leaf area (cm^2)	Yield (kg ha^{-1})	1000 kernel weight (g)	Test weight (kg)	Protein (%)
Kaya	0	88.3 d	9.5d	3140d	42.8b	68.5b	9.3c
	40	106.6 b	10.8d	4743c	48.5a	68.1b	9.8c
	80	104.3 c	15.8c	5622a	41.6b	68.7b	10.4bc
	120	107.8 b	19.2b	5219b	41.0b	70.4a	11.5ab
	160	119.3a	22.4a	4923c	41.7b	71.4a	11.8a
Mean		105.3	15.5	4729.4 b	43.1	69.4 b	10.6
Serife	0	84.7c	10.0c	3499d	48.8a	68.7b	9.8b
Hanim	40	104.9b	10.6c	4739c	47.4a	68.7b	10.5a
	80	111.4a	18.1b	5755a	45.3b	70.6a	10.7a
	120	112.7a	20.4a	5426b	45.9b	71.5a	11.5a
	160	103.8b	21.5a	5378b	47.9a	72.3a	11.7a
Mean		103.5	16.1	4959.4 a	47.1	70.4 a	10.8
LSD(nitro.)		2.15	1.90	23.88	2.35	1.78	1.30
LSD(Cult.)		11.86	2.43	526.95	6.77	0.86	1.52

Mean followed by different letter (s) are significantly different from one another at $p< 0.05$

Kaya (22.4 cm^2) gave significantly the highest flag leaf area with 160 kg ha^{-1} nitrogen. Serife Hanim (21.5 cm^2) had the highest value with 160 kg ha^{-1} nitrogen, too. When the nitrogen levels were increased, flag leaf area was affected positively.

In the view of thousand kernel weight, Kaya (48.5 g) had the highest value in 40 kg ha-1 nitrogen level, while Serife Hanim (48.8 g) had the highest value in control parcels. 1000 kernel weight of the barley for malting is one of the physical quality factors selected by the maltster and brewers (Surjawan et al., 2004). The values of test weight for Kaya were ranged from 68.1 kg (40 kg ha^{-1} nitrogen) to 71.4 kg (160 kg ha^{-1} nitrogen). The values for Serife Hanim were ranged from 68.7 kg (0 kg ha^{-1} nitrogen) to 72.3 kg (160 kg ha^{-1} nitrogen). Modern winter barley cultivars are capable of high yields with relatively high test weight (Alley et al., 1997). Data analysis resulting showed that, the levels of protein for Kaya ranged from 9.3 % to 11.8 %. The levels for Serife Hanim ranged from 9.8 % to 11.7 %. Generally, kernel and protein content are the dominant quality factors associated with malt barley production. Current dry land contracts specify a minimum of 75 % plump.

From the table 2, it was obtained that the both Serife Hanim (5755 kg ha^{-1}) and Kaya (5622 kg ha^{-1}) in nitrogen application of 80 kg ha^{-1} had the highest yield while control plots had the lowest values (3140 kg ha^{-1}, 3499 kg ha^{-1}, respectively) . When the regression equilibriums for both cultivars were estimated, it was clearly seen that the relationships between N levels and grain yield were quadratic. The equilibrium for S.Hanim was $Y = -0.175 x^2 + 39.12 x + 3510.3$ (R^2=0.958) and for Kaya was $Y = -0.227 x^2 + 46.39 x + 3195.3$ (R^2= 0.966). In the meanwhile, N level for maximum yield was estimated 102.27 kg ha^{-1} and 111.77 kg ha^{-1} for Kaya and Serife Hanim, respectively. Ruiter et al. (1999) revealed that it is difficult to achieve consistent high yield and high quality in variable growth environments. Jackson (2000) found that optimal yields occur near 160 kg ha^{-1} according to the regression equations between N and grain yield, and on average, available N should be 24 g N kg^{-1}. However, Ruiter et al. (1999) explained that higher than N losses could have occurred through leaching, gas emission and immobilization.

In the conclusions, when the nitrogen levels increased, plant height, flag leaf area, test weight and protein content resulted in increasing. Furthermore, barley yield showed quadratic curve for both cultivars. Although the difference between two cultivars was significant for yield, 100-112 kg ha^{-1} nitrogen level gave similar yield values for two cultivars. Therefore, this N level range should recommended for high yielding barley production and malting quality.

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