The Effect of Nitrogen Rates on Harmonization Ratio of Bread Wheat Cultivars

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ABSTRACT: The aim of this study was to evaluate the balance (harmonization ratio, HR) between vegetative period (VP) and grain filling period (GFP) based on thermal times for bread wheat cultivars (Seri-82, Genc-99 and Golia), and the effect of nitrogen rates (50, 100, 150, 200 and 250 kg N ha $^{-1}$) on this balance value. In the experiment, VP, GFP, days to maturity (DM), HR value and grain yield (GY) were evaluated and correlation coefficients were used to determine the relationships between these traits. HR values were significantly different for years, cultivars and nitrogen rates. Between the years, the highest HR value (0.419) and higher GY (7592.5 kg ha^{-1}) were obtained in 2001-02 cropping year compared to 2000-01 cropping year with lower HR value (0.366) and less GY (6584 kg ha^{-1}). Mean HR value was also calculated as 0.393 over all experiment data. However, cultivars were not significantly different for GY, while they were significantly different for HR value. However, both HR values and GY were around the mean values. All investigated traits were increased by nitrogen rates. The highest GY was obtained from 150 kg N ha^{-1} level with 7402 kg ha^{-1}, at this level HR value was 0.392 and it was almost equal to mean HR value (0.393) which was calculated over all the experiment data. The lowest GY was also obtained from 50 kg N ha^{-1} level with 6763 kg ha^{-1} GY, at this level HR was also lowest (0.369).
Key Words: wheat, grain filling period, vegetative period, harmonization ratio, grain yield.

Ekmeklik Buğday Çeşitlerinin Uyum İndeksine Azot Dozlarının Etkisi

ÖZET: Bu çalışmada vejetatif periyot (VP) ile tane dolum periyodu (TDP) arasındaki dengeyi (uyum indeksi, Uİ) ekmeklik buğday çeşitleri (Seri-82, Genç-99 ve Golia) ve azot dozunun (50, 100, 150, 200 ve 250 kg N ha $^{-1}$) bu denge değerine etkisini termal zamanlara göre değerlendirilmesi amaçlanmıştır. Araştırmada, VP, TDP, ekim olgunlaşma süresi (EOS), Uİ değeri ve tane verimi (TV) araştırılmış ve bu özellikler arasındaki ilişkileri belirlemek için korelasyon katsayıları kullanılmıştır. Uyum indeksi değerleri, yıllar, çeşitler ve azot dozları bakımından önemli derecede farklı bulunmuştur. Yıllar arasında en yüksek Uİ değeri (0.419) ve yüksek TV (7592.5 kg ha^{-1}) 2001-02 ürün yılından elde edilirken, 2000-01 ürün yılında daha düşük Uİ değeri (0.366) ve daha düşük TV (6584 kg ha^{-1}) elde edilmiştir. Araştırmada elde edilen verilere göre ortalama Uİ değeri ise 0.393 olarak hesaplanmıştır. Çeşitler TV bakımından istatistiki olarak farklı bulunmazken, Uİ bakımından önemli derecede farklı bulunmuşlardır. Bununla birlikte, hem Uİ hem de TV değerlerinin ortalama değerlere yakın olduğu da tespit edilmiştir. Bütün incelenen özellikler azot dozları ile birlikte artış göstermiştir. En yüksek TV 150 kg ha^{-1} azot seviyesinden 7402 kg ha^{-1} elde edilirken, bu azot seviyesinde Uİ değeri 0.392 olarak belirlenmiş ve bu değer ortalama Uİ (0.393) değerine yakın bir değer olmuştur. En düşük TV ise 50 kg ha^{-1} azot dozu seviyesinden 6763 kg ha^{-1} elde edilirken, bu azot dozu seviyesinde uyum indeksi değeri de (0.369) düşük olmuştur.
Anahtar Kelimeler: Buğday, tane dolum periyodu, vejetatif periyot, uyum indeksi, tane verimi.

INTRODUCTION

Genetic and environmental factors and their interactions (Dokuyucu et al., 1996; Öztürk and Akten, 1996) have effects on the duration of each phenological stage in wheat. Significant correlations between the durations of the developmental stages and absolute yield and yield components were reported (Rawson, 1970; 1971; Dokuyucu et al. 1996). Therefore, the factors modifying the durations of these stages are of great importance for grain yield. Factors such as sowing dates (Hay, 1986), temperature and photoperiod (Siddique et al., 1989; Slafer and Rawson, 1995), levels of nutrition (Öztürk and Akten, 1996; Rodriguez et al., 1994), water availability and water use efficiency (Siddique et al., 1990), plant densities (Öztürk and Akten, 1996; Miralles and Slafer, 2000 through Evans, 1987; Rawson, 1993) and their interactions (Slafer and Rawson, 1995) could be effected on the durations of phenological stages.

Gebeyehou et al. (1982) investigated rate and duration of grain filling in durum wheat cultivars. Siddique et al. (1989) calculated thermal times and compared dry matter production at the anthesis of the old and modern wheat cultivars in a Mediterranean-type environment.

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They also determined the ratio of dry matter production at this stage and its relations to grain yield. Corke and Kannenberg (1989) considered phenological stages as selection criteria and reported that optimal use of the limited heat units available for maize production in short season areas requires a balance between vegetative period duration and grain filling duration. However, in the literature, there is no available research on how this balance will be for the cereals? Meanwhile, Siddique et al. (1990) measured water use and water use efficiency of old and modern wheat cultivars in a Mediterranean-type environment to determine water use in the pre- and post-anthesis periods as well as their ratio. They indicated that much of the yield improvements achieved by wheat breeders were associated with a systematic change in the post- to pre-anthesis water use ratio. Lopez-Castaneda and Richards (1994) used thermal times and calendar days to evaluate the variation in temperate cereal species in rainfed environments for development and growth. They reported that barley (*Hordeum vulgare* L.) reached physiological maturity about 10 days (180 °C degrees) earlier than the other species and produced higher grain yield and biomass in a shorter than the other species. Jackson et al. (1994) pointed out the significant variation among the barley lines for grain yield, despite the very limited variation in time to anthesis. Akkaya et al. (2006) reported that there was significant relation between harmonization ratio and grain yield, and harmonization ratio may also be useful criteria for determination of genotypes with balanced post and pre-anthesis durations for higher grain yield. However, there is no available research related with the effect of nitrogen rates on HR values determining balance between VP and GFP.

Changing of the harmonization ratio (HR) by thermal times may have effects on GY capacity of genotypes in any given region or under the agricultural practices. Therefore, the aims of this article were; i-) to calculate harmonization ratios by thermal times for cultivars, years and nitrogen rates one of the most important agricultural practices and, ii-) to investigate relationships between HR and grain yield.

MATERIALS and METHODS

The research was conducted for two years, under rainfed conditions between 2000 and 2002 cropping years, in Kahramanmaraş province, which is located in the East-Mediterranean Region of Turkey. Climatic data belong to experiment years and long term for plant growth durations in Kahramanmaraş province are given in Table 1.

Table 1. Some average climatic data belong to experiment (2000-2002) and long term years (1960-2006) in Kahramanmaraş province

Months		Temperature (°C)			Rainfall (mm)			Relative Humidity (%)		
		2000-01	2001-02	Long term	2000-01	2001-02	Long term	2000-01	2001-02	Long term
November	Min	7.1	6							
	Max	20.8	15.8	12.0	54.5	56.1	59.3	63.4	64.0	72.5
	Mean	13.2	10.4							
December	Min	2.8	4.4							
	Max	11.4	9.3	6.5	102.7	258.2	118.9	76.3	79.8	61.1
	Mean	7.0	6.9							
January	Min	3.7	-0.7							
	Max	12.3	8.7	4.3	15.3	130.0	134.6	73.7	69.5	69.4
	Mean	7.7	3.5							
February	Min	3.1	3.8							
	Max	12.3	16.3	6.3	118.0	63.6	110.0	72.2	58.5	66.1
	Mean	7.6	9.8							
March	Min	9.1	6.7							
	Max	20.5	18.3	10.4	82.7	82.0	90.1	66.1	62.8	62.0
	Mean	14.7	12.5							
April	Min	10.8	9.3							
	Max	22	19.3	14.9	53.0	123.9	68.2	65.8	71.4	58.3
	Mean	16.4	14.0							
May	Min	13.7	13.9							
	Max	25.7	26.1	19.9	46.9	29.1	34.6	58.6	60.8	55.7
	Mean	19.8	19.6							
June	Min	19.6	19							
	Max	33.7	32.8	24.7	0.4	0.4	6.9	53.8	54.2	51.0
	Mean	26.4	25.7							
Total					473.5	743.3	622.6			
Mean	Min	8.6	7.8							
	Max	19.8	18.3	12.4				66.2	65.1	62.0
	Mean	14.1	12.8							

The factors were arranged as cultivars (Seri-82, Genc-99 and Golia) and nitrogen rates (50, 100, 150, 200 and 250 kg N ha^{-1}). The experiments were designed in a split plots arrangement on randomized complete block design (cultivars as main plots, nitrogen rates as subplots) with four replications. Planting was on 9^{th} November in 2000 and 17^{th} November in 2001, at the rate of 550 seed m^{-2} with 15 cm row-space with 8 row plots. Phosphorous was applied at the rate of 60 kg P_2O_5 ha^{-1} and nitrogen was applied at the half rate of the total nitrogen rate applications at planting. The rest of the nitrogen was applied at the tillering as topdressing. Herbicide used for weed control (Tribenuran-methyl (DF) 75%). Plots were harvested by plot combine.

The investigated traits; vegetative period (VP), grain filling period (GFP) and days to maturity (DM) were evaluated by thermal times (Gebeyehou et al., 1982; Lopez-Castaneda and Richards 1994 and Akkaya et al., 2006). The Celsius scale was used, with a base of 0 °C, for thermal time's calculations for VP, GFP and DM, the abbreviations; VP_{tt}, GFP_{tt}, DM_{tt} for thermal times were used, respectively. Harmonization ratio by thermal times were calculated by the formula; $\mathbf{HR_{tt} = GFP_{tt}/VP_{tt}}$ (Akkaya et al., 2006). Grain yield (GY) was also determined by weighing of grain products obtained from the plots, harvested after excluding of side effects. The data belong to the experiment was analyzed for variance test and means were ranked according to LSD test and correlation coefficients were used to determine the relations between investigated traits (SAS, 1999).

RESULTS and DISCUSSION

Average value of years, cultivars and nitrogen rates for VP_{tt}, GFP_{tt}, DM_{tt}, HR_{tt} and GY are shown in Table 2, 3 and 4. Results show that the effect of years and nitrogen rates on GY, VP_{tt}, GFP_{tt}, DM_{tt} and HR_{tt} were significant (*P*<0.01). All values for investigated traits in the 2001-02 cropping year were significantly higher than those in 2000-01 crop season. These results were due to climatic changes between the years, especially higher rainfall in the second year (Table 1). In favorable years, GY VP_{tt}, GFP_{tt} and DM_{tt} were tended to be higher; especially increasing of GFP_{tt} was higher than increasing of VP_{tt}. This situation was also leaded to increase HR_{tt} value. Therefore, harmonization ratio (0.419) was also higher in 2001-02 year with higher GY (7592.5 kg ha^{-1}) compared to 2000-01 year with lower HR_{tt} (0.366) and less GY (6584 kg ha^{-1}) (Table 2). Favorable conditions could cause to increase HR_{tt} as well as GY. In previous works, significant differences were reported for VP, GFP, DM and GY between the years due to climatic changes (Pirasteh and Welsh, 1980; Fischer, 1984; Davidson et. al., 1985; Hay and Kirby, 1991; Slafer and Rawson, 1995) and water availability (Siddique et al., 1990). Akkaya et al. (2006) also reported higher HR_{tt} values with high GY across the years. In view of these results, HR_{tt} values may be used for characterization of the years or environments that have high yield capacities.

Table 2. Average values and LSD groups of VP_{tt}, GFP_{tt}, DM_{tt} by the thermal times, and calendar days in parenthesis, HR values and GY for years.

	VP_{tt} (days)	GFP_{tt} (days)	DM_{tt} (days)	HR_{tt}	GY (kg ha^{-1})
Years	**	**	**	**	**
2000-01	1693b (164.6)	621 b (32.8)	2314 b (197.4)	0.366 b	6584 b
2001-02	1736 a (167.3)	728 a (37.7)	2463 a (205.1)	0.419 a	7592 a
Mean	1714 (165.9)	674 (35.2)	2389 (201.2)	0.393	7088
LSD (0.05)	5.393	9.53	12.612	0.005	264.5
CV %	0.864	3.883	1.451	3.665	10.25

Level of statistical significance: ** *P*<0.01.

Cultivars were also significantly different for VP_{tt}, HR_{tt} (*P*<0.05), GFP_{tt} and DM_{tt} (*P*<0.01). However, they were not significantly different for GY, this situation may be due to they are standard cultivars and commonly grown in the region. Nevertheless, Golia cv. with the highest HR_{tt} (0.400), tended to have higher GY, it is gradually more preferred by farmers for planting in large and irrigated areas of the region, because of its lodging resistance and higher GY capacity compared to the other cultivars (Table 3). In addition, the previous authors were pointed out differences among GY, VP, GFP and DM calculated by the both thermal times and calendar days for the cultivars (Siddique et al., 1989; Lopez-Castenada and Richards, 1994; Öztürk and Akten, 1996; Dokuyucu et al., 1996). On the other hand, cultivars were similar for VP_{tt}, GFP_{tt}, DM_{tt} and HR_{tt} values. This similarity also made HR_{tt} values more dependable compared to VP_{tt}, GFP_{tt} and DM_{tt}. Because, HR_{tt} value was calculated by consideration of both VP_{tt} and GFP_{tt}, and this HR_{tt} value may help to determine the balance between GFP_{tt} and VP_{tt}. In previous work, Akkaya et al. (2006) also reported significant differences among cultivars for HR_{tt} value. Akkaya et al. (2006) also stated that, cultivars with higher HR_{tt} values had higher GY. Cultivars used in this study were commonly grown in the region and their GY and HR_{tt} values were around the mean of the region. In addition, changing of development stage durations depends on genetics of the genotypes in any given environment. For this reason, total thermal unit of genotypes in GFP should coincide with the days having the optimum temperatures for growing. Harmonization ratio may help to evaluate the balance between VP_{tt} and GFP_{tt} of genotypes by the thermal times or calendar days for higher GY capacity (Akkaya et al., 2006). Similarly, Siddique et al. (1990) experienced water use and water use efficiency of old and modern wheat cultivars in a Mediterranean-type environment to determine water use in the pre- and post- anthesis periods as well as their ratio. Therefore, it is concluded that yield improvements achieved by wheat breeders may be associated to a systematic change in the post- to pre-anthesis water use ratio. In our research, total thermal times of post and pre-anthesis periods as well as their ratios also had effects on growing. It is possible to say that determination of HR_{tt} values by using VP_{tt} and GFP_{tt} could help to characterize genotypes having balanced VP and GFP durations and adaptations to different environments. In a previous work, it is reported that it might be possible to evaluate genotypes by their optimum, lowest and highest HR_{tt} values (Akkaya et al., 2006).

Table 3. Average values and LSD groups of VP_{tt}, GFP $_{tt}$, DM $_{tt}$ by the thermal times and calendar days in parenthesis, HR values and GY for three bread wheat cultivars

	VP_{tt} (days)	GFP_{tt} (days)	DM $_{tt}$ (days)	HR $_{tt}$	GY (kg ha^{-1})
Cultivars	*	**	**	*	ns
Seri-82	1710 b# (165.8)	663 b# (34.9)	2373 b# (200.7)	0.387 b#	7172
Genc-99	1719 a (166.3)	674 b (34.7)	2394 a (201.3)	0.392 b	7025
Golia	1713 b (165.8)	686 a (36.0)	2400 a (201.8)	0.400 a	7067
Mean	1714	674	2389	0.393	7088
LSD (0.05)	6.61	11.67	15.45	0.006	324.0

ns: not significant; level of statistical significance: * P<0.05, ** P<0.01.
Values with the same letter are not statistically different at P< 0.05.

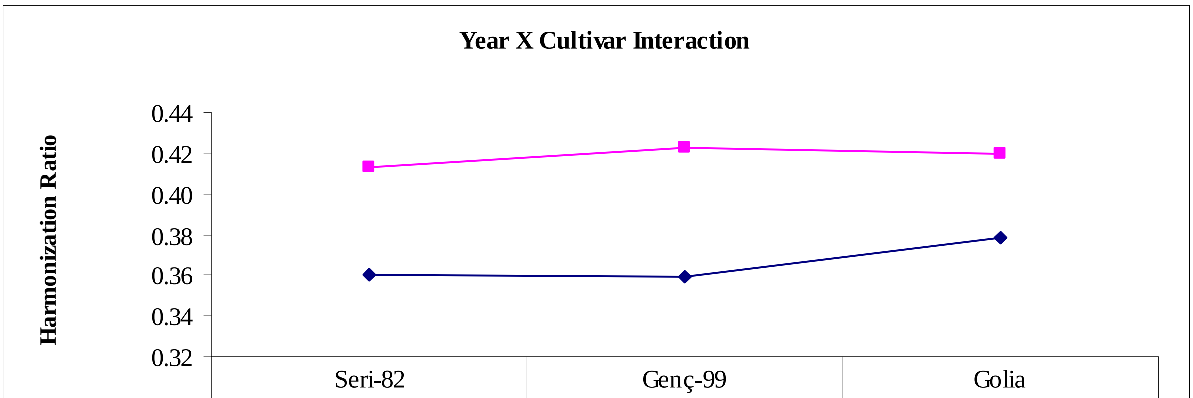
Table 4. Average values and LSD groups of VP_{tt}, GFP $_{tt}$, DM $_{tt}$ by thermal times and calendar days in parenthesis, HR values and GY for nitrogen rates.

	VP_{tt} (days)	GFP_{tt} (days)	DM $_{tt}$ (days)	HR $_{tt}$	GY (kg ha^{-1})
Nitrogen Rates (kg ha^{-1})	**	**	**	**	*
50	1700 d (165)	629 e (33.7)	2329 e (198.7)	0.369 e	6763 c
100	1704 cd (165.5)	648 d (34.6)	2352 d (200.1)	0.379 d	6906 bc
150	1709 c (165.6)	670 c (35.6)	2380 c (201.2)	0.392 c	7402 a
200	1723 c (166.5)	700 b (35.6)	2423 b (202.4)	0.406 b	7294 ab
250	1735 a (167.3)	725 a (36.5)	2460 a (203.9)	0.418 a	7075 abc
Mean	1714	674	2389	0.393	7088
LSD (0.05)	8.53	15.07	19.94	0.008	418.31

Level of statistical significance: * P<0.05, ** P<0.01.

The effect of nitrogen rates were also significant for GY (P<0.05), VP_{tt}, GFP_{tt}, DM_{tt} and HR_{tt} (P<0.01). GY was significantly increased by increasing nitrogen rates. Increasing GY by nitrogen rates was also reported in previous works (Pala et al., 1992; Mosseddaq and Farihane, 1992; Oweiss and Pala, 1996; Seput et al., 1996). Rodriguez et al. (1994) also reported that the effect of the rates and level of nutrition on the traits of genotypes. Öztürk and Akten (1996) also reported increasing on VP, GFP and DM with increasing nitrogen rates, which is in agreement with our results. However, in our work, increasing ratio of GFP was higher than VP. This situation was due to higher rainfall in April 2002, and May 2001. This also caused increasing HR value by increasing nitrogen rates. The lowest GY (6763 kg ha^{-1}) was obtained from 50 kg N ha^{-1} nitrogen rate, while HR_{tt} (0.369) was also calculated as the lowest. The highest GY (7402.1 kg ha^{-1}) was obtained from 150 kg ha^{-1} nitrogen level, and at this level, HR value (0.391) was almost equal to average HR value of the experiment. For optimum HR_{tt} values it was determined that calculated HR_{tt} value over the whole experiment data was usually equal or near to HR_{tt} value obtained from 150 kg N ha^{-1} level which was supplied the highest GY. GY tends to decrease at 200 kg N ha^{-1} level. On the other hand, at 200 and 250 kg ha^{-1} nitrogen rates, HR_{tt} values were calculated as 0.406 and 0.418. It caused decreasing of GY, but this decreasing was not significant (Table 4). This situation could be explained by the deviation of HR values from optimum level by increasing nitrogen application.

It may be expected lower HR value due to increasing of VP by increasing of nitrogen rates. However, increasing of nitrogen caused increasing of both VP, GFP and as well as HR value. This situation was due to higher increasing ratio in GFP. This kind of HR deviations by changing VP_{tt} and GFP_{tt}, may cause decreasing of GY. However, this GY decreasing was not significant in our experiment. Higher HR_{tt} may be expected in the favorable conditions, but decreasing of GY might be also expected after a level of HR_{tt} because of deterioration of balance between GFP_{tt} and VP_{tt}. Long-standing of GFP_{tt} and VP_{tt} could lead to delaying of maturity into hot summer days in the region. Year x cultivar interaction was significant for HR and is given in Fig. 1. Response of cultivars to the years for HR_{tt} was significantly different. This situation may also be attributed to the effect of climatic factors on cultivars especially higher rainfall in 2001-02 cropping year and rainfall in March and April months in 2000-01 cropping year; it was less than average of the long term years and 2001-02 cropping year (Table 1). This situation caused shorter VP_{tt} and GFP_{tt} as well as lower HR_{tt} values in 2000-01 year for cultivars. Year x nitrogen rate interaction had significant effect on HR_{tt} values (Fig. 2). Harmonization ratio was significantly different for years and nitrogen rates. HR_{tt} values were higher in 2001-02 cropping year than 2000-01 cropping year. While thermal times (1714) on VP occurred in a long period (165.9 days) due to low temperature, thermal times (674) on GFP occurred in a shorter period (35.2 days) due to higher temperature. This situation might be due to higher rainfall in 2001-02 cropping year, in which total rainfall higher than average long-term rainfall. In 2001-02 cropping year; there was no significant changing for HR_{tt} value by increasing nitrogen rates. However, in 2000-01 cropping year, which had less rainfall than average rainfall in long-term years and 2001-02 cropping year, HR_{tt} value significantly increased due to increasing nitrogen rates. This situation might be due to less effect of nitrogen rates in VP due to less rainfall and higher average temperature in April and higher effect of nitrogen during GFP in May due to higher rainfall in 2000-01 crop season than long term years and 2001-02 crop season (Table 1). In addition, the effect of nitrogen rates for HR_{tt} value might be covered by higher rainfall in the second year of the experiment. Aitken (1974) reported that temperature alone has a universal impact on the wheat development, Slafer and Rawson (1995) also reported that the higher temperature, the faster rate of development and consequently the shorter times to complete a particular developmental stage and development can be different in any given environment due to change of temperature in the years. Therefore, this effect of temperature would be similar in the limits of any environment. This also means that HR values calculated over the thermal times or days of cultivars maybe criteria in characterization of adaptation ability of cultivars for environments.



	Seri-82	Genç-99	Golia
2000-01	0.360	0.359	0.379
2001-02	0.413	0.423	0.420

Figure 1. The effect of year x cultivar interaction on HR_{tt}

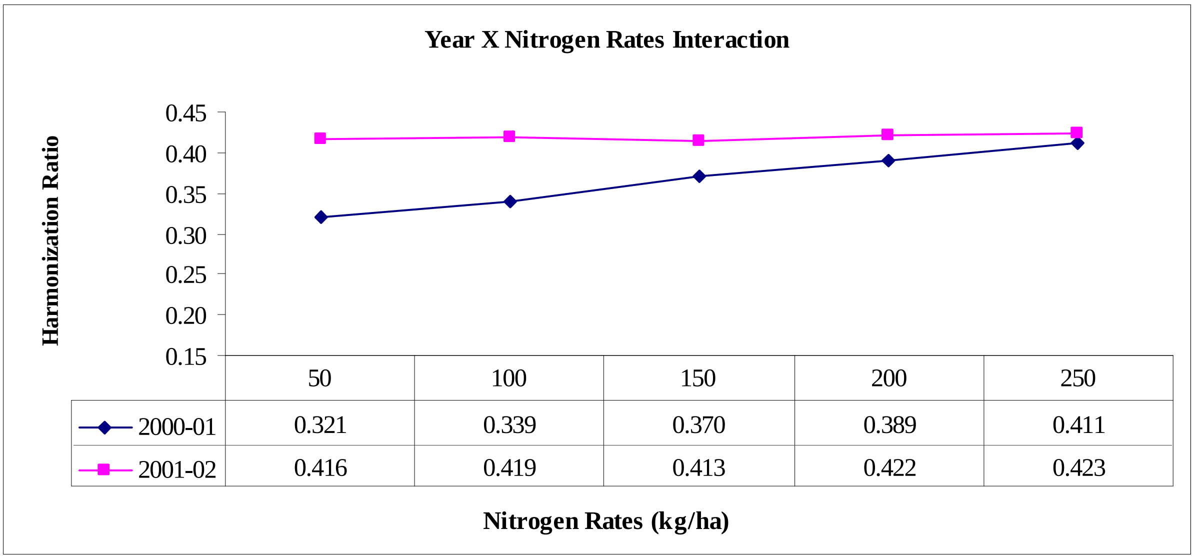


Figure 2. The effect of year x nitrogen rate interactions on HR_{tt}

Correlation Coefficients

Correlation coefficients between GY and VP_{tt}, GFP_{tt}, DM_{tt} and HR_{tt} for the experiment were calculated and are given in Table 5. GY was correlated significantly and positively with VP_{tt}, GFP_{tt} and DM_{tt}. Some researchers have pointed out significant correlations between GY and VP, GFP and DM (Rawson, 1970 and1971; Rawson and Bagga, 1979; Gebeyehou et al., 1982; Corke and Kannenberg, 1989; Dokuyucu et al., 1996). HR_{tt} values were also significantly and positively correlated with GY in the experiment, Akkaya et al. (2006) pointed out that in Kahramanmaraş province for durum wheat cultivars, there was significant and positive relationship between HR_{tt} and GY.

Table 5. Correlation coefficients between GY and VP_{tt}, GFP_{tt}, DM_{tt} and HR_{tt}

Traits	VP_{tt}	GFP_{tt}	DM_{tt}	HR_{tt}
GY	0.363 **	0.408 **	0.408 **	0.404 **

Level of statistical significance: ** $P<0.01$.

CONCLUSIONS

According to the results of experiment, HR values were significantly different for the years, cultivars, and nitrogen rates.

HR_{tt} value, which was also generally equal to mean of HR_{tt} value, calculated over the all experiment data may be accepted as optimum. This value was mostly equal or near to HR_{tt} value obtained from 150 kg N ha^{-1}, which had the highest GY. Harmonization ratios were significantly different for the years as well as nitrogen rates. It indicates that favorable conditions could lead increasing both GY and HR_{tt}. Therefore, it is important to apply agricultural practices, which will improve HR_{tt} and GY. HR_{tt} value may help to adjust the agricultural practices. In addition, determination of optimum HR_{tt} values may be important for any given genotypes, environments and agricultural practices. Especially, determination of genotypes with optimum HR_{tt} value may lead to increase GY. Briefly, we can say that there are some interesting results relating with HR_{tt} in this experiment. However, it is necessary more experiments to be carried out in different environments and conditions with different varieties for more information.

REFERENCES

Aitken, Y. 1974. Flowering Time, Climate and Genotype. Melbourne University Press, Melbourne, 193s.

Akkaya, A., Dokuyucu, T., Kara, R., Akçura, M. 2006. Harmonization Ratio of Post- to Pre-anthesis Durations by Thermal Times for Durum Wheat Cultivars in a Mediterranean Environment. European J. of Agron., 24 (4): 404-408.

Corke, H., Kannenberg, L.W. 1989. Selection for Vegetative Phase and Actual Filling Period Duration in Short Season Maize. Crop Sci., 29: 607-612.

Davidson, J.L., Christian, K.R., Jones, D.B., Bremner, P.M. 1985. Responses of Wheat to Vernalization and Photoperiod. Aust. J. of Agric. Res., 36: 347-359.

Dokuyucu T., Akkaya, A., Ispir, B., Cesurer, L. 1996. Flag Leaf Area and Duration, Phenological Stages and Their Relations to Grain Yield of some Durum Wheat (*T. durum* Desf.) Varieties in Kahramanmaraş Conditions. V. International Wheat Conference, June 10-14, Ankara-Turkey.

Evans, L.T. 1987. Short Day Induction of Inflorescence Initiation in Some Winter Wheat and Its Wild Relatives. Aust. J. of Pant Physiol., 14: 277-286.

Fischer, R.A. 1984. Wheat. (Symposium on Potential Productivity of Field Crops under Different Environments IRRI, Los Banos: Eds. Smith, W. H., Banta S.I.) 129-153.

Gebeyehou, G., Knott, D.R., Baker R.J. 1982. Rate and Duration of Grain Filling in Durum Wheat Cultivars. Crop Sci., 22: 337-340.

Hay, R.K.M. 1986. Sowing Date and the Relationships between Plant and Apex Development in Winter Cereals. Field Crops Res., 14: 321-337.

Hay R.K.M., Kirby, E.J.M. 1991. Convergence and Synchrony-a Review of the Coordination of Development in Wheat. Aust. J. of Agric. Res., 42: 661-700.

Jackson, P.A., Byth, D.E., Fischer, K.S., Johnstan, R.P. 1994. Genotype x Environment Interactions in Progeny from a Barley Cross II. Variation in Grain Yield, Yield Components and Dry Matter Production among Lines with Similar Times to Anthesis. Field Crops Res., 37: 11-23.

Lopez-Castaneda, C., Richards, R.A. 1994. Variation in Temperate Cereals in Rainfed Environments II. Phasic Development and Growth. Field Crops Res., 37: 63-75.

Miralles D.J., Slafer, G.A. 2000. Wheat Development. (Wheat Ecology and Physiology of Yield Determination. Food Products Press, Binghamton: Eds. Satorre, E. H., Slafer, G.A.) 23-24.

Mosseddaq, F., Farihane, H. 1992. Nitrogen Fertilization of Cereal: Soil-Plant System Nitrogen Dynamics. Proceedings of The Fourth Regional Workshop on Fertilizer Use Efficiency under Rain-fed Agriculture in West Asia and North Africa,5-10 May, Agadir-Morocco.

Oweiss, T., Pala, M. 1996. Response of Some Bread and Durum Wheat Varieties to Supplemental Irrigation, Nitrogen and Date of Planting. V. International Wheat Conference, June 10-14, Ankara- Turkey.

Öztürk, A., Akten, Ş. 1996. The Effects of Nitrogen and Sowing Density on Vegetative Period, Grain Filling Period and Grain Filling Rate of Winter Wheat Genotypes. V. International Wheat Conference, June 10-14, Ankara- Turkey.

Pala , M., Matar, A., Mazid, A., Hajj, K.E. 1992. Wheat Response to Nitrogen and Phosphorus Fertilization under Various Environmental Conditions of Northern Syria. Proceedings of The Fourth Regional Workshop on Fertilizer Use Efficiency under Rainfed Agriculture in West Asia and North Africa, 5-10 May, Agadir-Morocco.

Pirasteh, B., Welsh, J.R. 1980. Effect of Temperature on the Heading Date of Wheat Cultivars under A Lengthening Photoperiod. Crop Sci., 20: 453-456.

Rawson, H. M. 1970. Spikelet Number, Its Control and Relation to Yield per Ear. Aust. J. of Biological Sci., 23: 1-5.

Rawson, H.M. 1971. An upper Limit for Spikelet Number per Ear in Wheat as Controlled by Photoperiod. Aust. J. of Agric. Res., 22: 537-546.

Rawson, H.M., Bagga, A.K. 1979. Influence of Temperature between Floral Initiation and Flag Leaf Emergence on Grain Number in Wheat. Aust. J. of Pant Physiol., 6: 391-400.

Rawson, H.M. 1993. Radiation Effects on Development Rate in Spring Wheat Grown under Different Photoperiods and High and Low Temperatures. Aust. J. of Pant Physiol., 20: 719-727.

Rodriguez, D., Santa Maria, G.E., Pomar, M.C. 1994. Phosphorous Deficiency Affects the Early Development of Wheat Plants. J. of Agron. and Plant Sci., 116: 1-7.

SAS Institute, 1999. SAS/STAT User's guide. 8th Version, SAS Inst. Inc. Cary, NC.

Seput, M., Kelecenji, Z., Sipic, M. 1996. Wheat Response to Fertilization on Hypogley Soil of The Eastern Croatia. V. International Wheat Conference, June 10-14, Ankara- Turkey.

Siddique, K.H.M., Belford, R.K., Perry, M.W., Tennant, D. 1989. Growth, Development and Light Interception of Old and Modern Wheat Cultivars in a Mediterranean-Type Environment. Aust. J. Agric. Res., 40: 473-487.

Siddique, K.H.M., Tennant, D., Perry, M.W., Belford, R.K. 1990. Water Use Efficiency of Old and Modern Wheat Cultivars in Mediterranean-Type Environment. Aust. J. Agric. Res. 41: 431-447.

Slafer, G.A., Rawson, H.M. 1995. Does Temperature Affect Final Numbers of Primordial in Wheat? Field Crops Res., 39: 111-117.