KSÜ Doğa Bil. Derg., 19(3):305-309, 2016
KSU J. Nat. Sci., 19(3):305-309, 2016

Araştırma Makalesi
Research Article

Can We Use a Traditional Unit as a New Component in Scientific Researches?

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Geliş (Received): 08.02.2016 **Kabul** (Accepted): 14.05.2016

ABSTRACT: The farmers of our modern world still use a traditional unit, "at how fold", when they consider the effects of treatments on yield. This traditional unit could be useful especially for considering the efficiency of planting density. In this research, we replaced the term "at how fold" by the term "density yield coefficient". We hypothesized that variations caused by planting density could be explained by the density yield coefficient better than by the grain yield itself. In order to test this hypothesis, two experiments were carried out in the East Mediterranean climate conditions in Turkey, in 2012-2013 crop years. Each experiment included 6 seeding rates (200, 300, 400, 500, 600 and 700 seeds m^{-2}) and 2 wheat cultivars. The experimental designs were the randomized complete block design with factorial arrangement. The linear and quadratic relationships between grain yield and seeding rates were significant in bread wheat varieties, while nonsignificant in durum wheat. Whereas the linear and quadratic relationships between seeding rates and density yield coefficients were significant in bread and durum wheat. The values of R^2 belonging to linear and quadratic relationships between the seeding rate and the density yield coefficient were much higher than those between the seeding rate and the grain yield. These results indicate that the density yield coefficient could be a more determinative component in explaining of variation caused by seeding rate, compared to grain yield itself.
Key Words: Wheat, seeding rate, grain yield, density yield coefficient

Geleneksel Bir Ölçüyü Bilimsel Araştırmalarda Yeni Bir Unsur Olarak Kullanabilirmiyiz?

ÖZET: Modern dünyamızın yetiştiricileri, uygulamaların verim üzerindeki etkilerini değerlendirirken geleneksel bir birim olan "bir'e kaç" ölçüsünü kullanmaktadır. Bu geleneksel ölçü, özellikle ekim sıklığı etkinliğinin değerlendirilmesinde oldukça yararlı olabilir. Bu araştırmada, geleneksek olarak kullanılan "bir'e kaç" terimi, "sıklık verim katsayısı" şeklinde değiştirilerek kullanılmıştır. Araştırma, ekim sıklığına bağlı varyasyonların, tane verimine göre, sıklık verim katsayısıyla daha iyi açıklanabileceği hipotezi üzerine kurulmuştur. Bu hipotezi test etmek için, Doğu Akdeniz iklim koşullarında 2012-2013 ürün yılında, ekmeklik ve makarnalık buğdaylarda olmak üzere iki deneme kurulmuştur. Her bir denemede 6 ekim sıklığı (200, 300, 400, 500, 600 ve 700 tohum m^{-2}) ve 2'şer çeşit kullanılmıştır. Denemeler faktöriyel düzenleme yapılarak, tesadüf blokları deneme planına göre 4 tekerrürlü olarak yürütülmüştür. Ekmeklik buğday çeşitlerinde tane verimi ile ekim sıklığı arasındaki linear ve quadratik ilişki istatistiki olarak önemli bulunurken, makarnalık buğday çeşitlerinde önemsiz olmuştur. Ancak, sıklık verim katsayısı ile ekim sıklığı arasındaki linear ve quadratik ilişki, hem ekmeklik hem de makarnalık buğdayda istatistiki olarak önemli bulunmuştur. Sıklık verim katsayısı ile ekim sıklığı arasındaki linear ve quadratik ilişkilere ait R^2 değerleri, ekim sıklığı ile tane verimi arasındaki linear ve quadratik ilişkilere ait R^2 değerlerinden oldukça yüksek olmuştur. Bu sonuçlar, ekim sıklığından kaynaklanan varyasyonların açıklanmasında, tane verimine göre, sıklık verim katsayısının daha belirleyici olabileceğini göstermektedir.
Anahtar Kelimeler: Buğday, ekim sıklığı, tane verimi, sıklık verim katsayısı

INTRODUCTION

The several traits of wheat genotypes such as agronomic, morphologic, phenologic, physiologic, ecologic, genetic and quality traits, are generally investigated in scientific studies. For example, the grain yield, biomass, harvest index, plant height, spike height, spike number, grain number and weight per spike, test weight are commonly tested in wheat field trials all over the world. However, the wheat producers generally take into account only the grain yield and they consider effects of treatments and inputs based on grain yield. Similarly to consideration of ancient centuries (Sinclair, 1998), the farmers of our modern world still use a traditional unit, "at how fold", when they consider the effects of treatments on yield.

Although this traditional unit has been commonly used by wheat farmers, it had not been taken into account in the scientific researches. In the literature, we could not reach any research article used this traditional unit as a component in wheat crop. We could only find out the very short information about it in a review article written by Sinclair (1998). This traditional unit could be useful especially for considering the efficiency of planting density in wheat crop.

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In this research, we replaced the term "at how fold" by the term "density yield coefficient". The density yield coefficient means yield level over what is sown. In other words, this coefficient reflects the yielding efficiency of seeding rate. We hypothesized that the density yield coefficient compared to grain yield itself could be more useful to explain variations caused by sowing density. The aim of this research was to test this hypothesis in different seeding rates of bread and durum wheat varieties in Mediterranean conditions in Turkey.

MATERIALS and METHODS

Site description and agronomic applications

These field experiments were conducted during growing season 2012-2013 under rainfed conditions in Kahramanmaraş located in East Mediterranean Region of Turkey. The location has typical Mediterranean climate with about 700 mm annual precipitation and 13°C mean temperature. The soil texture is silty loam with near 8.0 pH, 1 % organic matter, 80 kg ha^{-1} available phosphorus and 1300 kg ha^{-1} available potassium.

The planting was done by plot drill at the beginning of January. The plot size was 1m x 8 m = 8 square meter, including 6 plant rows with 20 cm row space. The fertilizers were applied at the rates of 80 kg ha^{-1} N and P2O5 during planting and 100 kg ha^{-1} at the beginning of stem elongation as top dressing. Herbicide was applied at the tillering stage for weed control. Harvest was done by plot combine from the 0.8 m x 7.0 m = 5.6 square meter harvest area.

Treatments and experimental design

The treatments were 6 seeding rates (200, 300, 400, 500, 600 and 700 seeds m^{-2}) and 2 cultivars in each trial (cultivars Ceyhan 99 and Dariel in bread wheat trial and cultivars Zenit and Kunduru-1149 in durum wheat trial). The bread and durum wheat experiments were separately conducted in a randomized complete block design with factorial arrangement with four replications.

Traits and statistical analysis

The grain yield was determined by weighing the grain product of each plot after threshing. The following equations were used in the calculations of density yield coefficients.

SWH =SWS X 10000 (1)
DYC = GYH / SWH (2)
Where;
SWH; seed weight per hectare for each sowing density (kg ha^{-1}),
SWS; seed weight per square meter for each sowing density (kg m^{-2}) X 10000,
GYH; grain yield per hectare (kg ha^{-1}),
DYC; density yield coefficient,

For variance analysis ANOVA procedure was performed and Fisher's least significance difference test (P=0.05) was used for comparing the mean differences. The linear and quadratic regression analyses were performed to compare R^2 values related grain yield and density yield coefficient. All statistical analyses were performed using SAS software (SAS Institute, 2002).

RESULTS

Grain yield

The grain yields of bread and durum wheat varieties obtained from different seeding rates are shown in Table 1. There were significant effects of seeding rates on grain yield in bread and durum wheat. The grain yield increased by increasing seeding rates until 500 seeds m^{-2}, but seeding rates more than 500 seeds m^{-2} could not provide significant yield increases in bread wheat. In durum wheat, the highest grain yield was obtained at 600 seeds m^{-2} and there were no significant differences among other seeding rates.

The results of linear and quadratic regression analysis between seeding rates and grain yield of bread wheat are given in Table 2. In bread wheat varieties, the linear and quadratic relationships between grain yield and seeding rates were significant (P<0.01).

The results of linear and quadratic regression analysis between seeding rates and grain yield of durum wheat varieties are presented in Table 3. In contrary to bread wheat, the linear and quadratic relationships between grain yield and seeding rates in durum wheat were not significant ($P>0.0^5$). The R^2 values belonging to linear and quadratic relationships were too low (0.73 and 1.83%, respectively).

Density yield coefficient

The density yield coefficient of bread and durum wheat varieties by seeding rates are shown in Table 4. The increasing seeding rates caused significant decreases in density yield coefficients in bread and durum wheat. Based on means over cultivars, the highest coefficients were obtained at 200 seeds m^{-2} rate in bread and durum wheat, 69 and 48 respectively. The density yield coefficients significantly and gradually decreased from 69 to 23 in bread wheat, from 48 to 14 in durum wheat, by increasing seeding rates.

The results of linear and quadratic regression analysis between seeding rates and density yield coefficients are given in Tables 5 and 6. The linear and quadratic relationships between seeding rates and density yield coefficients were significant in bread and durum wheat. On the other hand, R^2 values belonging to linear and quadratic relationships were 71.98 and 78.32% respectively in bread wheat, 72.34 and 78.24% respectively in durum wheat. As it can be seen from related tables, R^2 values of linear and quadratic relationships in density yield coefficient were much higher than those in grain yield.

Table 1. Grain yields of bread and durum wheat varieties by seeding rates (kg ha^{-1})*

	Seeding rates (seed m^{-2})						
Bread wheat varieties	200	300	400	500	600	700	Means
Ceyhan 99	4880	5260	5390	5410	5620	5410	5330b
Dariel	5050	5500	5610	5840	6160	5910	5680a
Means	4970c	5380b	5500b	5630ab	5890a	5660ab	
Durum wheat varieties							
Zenit	3340	3840	4090	5290	6340	4590	4580a
Kunduru 1149	4660	4330	4690	3410	3790	3550	4190b
Means	4000b	4090b	4390b	4350b	5060a	4070b	

*Differences among means with same letters in bread and durum wheat are not significant at the 0.05 probability level

Table 2. Regression analysis of linear and quadratic relationships between seeding rate and grain yield in bread wheat

Source of variation	Degree of freedom	Sum of squares	Mean square	F values	Probability
Linear regression	1	29813	29813	17.50**	$P < 0.01$
Residual	46	78406	1704		
Total	47	108219			
R^2 = 26%; Regression equation; Grain yield = 499.3 + 14.59 x seeding rate.					
Quadratic regression	2	36451	18225	11.43**	$P < 0.01$
Residual	45	71768	1595		
Total	47	108219			
R^2 = 31 %; Regression equation; Grain yield = 455.3 + (47.59 x seeding rate) + (-4.71 x seeding rate^2)					

**Significant at the 0.01 probability level

Table 3**.** Regression analysis of linear and quadratic relationships between seeding rate and grain yield in durum wheat

Source of variation	Degree of freedom	Sum of squares	Mean square	F Values	Probability
Linear regression	1	12053	12053	1.34	$P > 0.05$
Residual	46	412516	8968		
Total	47	424569			
R^2 = 0.73 %; Regression equation; Grain yield = 400.2 + 9.3 x seeding rate.					
Quadratic regression	2	25517	12759	1.44	$P > 0.05$
Residual	45	399051	8868		
Total	47	424569			
R^2 = 1.83 %; Regression equation; Grain yield = 337.5 + (56.3 x seeding rate) + (-6.7 x seeding rate^2)					

Table 4. Density yield coefficients in bread and durum wheat varieties*

	Seeding rate (seed/m^2)						
Bread wheat varieties	200	300	400	500	600	700	Means
Ceyhan 99	57	41	32	26	22	18	33b
Dariel	80	59	45	38	32	27	47a
Means	69a	50b	38c	32d	27e	23f	
Durum wheat varieties							
Zenit	41	32	25	26	26	16	28
Kunduru 1149	55	34	28	16	15	12	27
Means	48a	33b	26c	21d	20d	14e	

*Differences among means with same letters in bread and durum wheat are not significant at the 0.05 probability level

Table 5. Regression analysis of linear and quadratic relationships between seeding rate and density yield coefficient in bread wheat

Source of variation	Degree of freedom	Sum of squares	Mean square	F values	Probability
Linear regression	1	10614	10614	122**	P < 0.01
Residual	46	4010	87		
Total	47	14624			
R^2 = 71.98%; Regression equation; Density yield coefficient = 70.2 + (-8.7 x seeding rate).					
Quadratic regression	2	11588	5794	86**	P < 0.01
Residual	45	3036	67		
Total	47	14624			
R^2 = 78.32%, Regression equation; Density yield coefficient = 87 + (-21.3 x seeding rate) + (1.8 x seeding rate^2)					

**Significant at the 0.01 probability level

Table 6. Regression analysis of linear and quadratic relationships between seeding rate and density yield coefficient in durum wheat

Source of variation	Degree of freedom	Sum of squares	Mean square	F values	Probability
Linear regression	1	5222	5222	124**	P < 0.01
Residual	46	1938	42		
Total	47	7160			
R^2 = 72.34%, Regression equation; Density yield coefficient = 48.5 + (-6.1 x seeding rate).					
Quadratic regression	2	5668	2834	86**	P < 0.01
Residual	45	1492	33		
Total	47	7160			
R^2 = 78.24%, Regression equation; Density yield coefficient = 60 + (-14.6 x seeding rate) + (1.2 x seeding rate^2).					

**Significant at the 0.01 probability level

DISCUSSION

There were significant effects of seeding rates on grain yield in bread and durum wheat. There are several studies in the literature reporting significant effects of seeding rates on grain yield of wheat varieties (Blue et al., 1990; Carr et al., 2003; Dai et. al., 2013; Sun et.al., 2013). In Mediterranean climate, Arduini et. al., (2006) reported that the grain yield was highest with 400 seeds m^{-2}, primarily due to the higher number of spikes per unit area. In another study, it was reported that the highest yields were obtained from at least 400 to 500 plants m^{-2} for most of the varieties in Mediterranean conditions (Lloveras et al., 2004).

The linear and quadratic relationships between grain yield and seeding rates were significant in bread wheat, while nonsignificant in durum wheat. Although significant linear and quadratic relations in bread wheat, R^2 values were very low, 26 and 31%, respectively (Table 2). Lloveras et al. (2004) reported that the seeding rates affected grain yield with significant linear and quadratic trends. In another study, it was indicated that the grain yield increased linearly with increasing seeding rate in three of four environments (Geleta et al., 2002).

There were fluctuations in the grain yield by increasing seeding rates, while the density yield coefficient gradually and significantly decreased by increasing seeding rates (Figures 1 and 2). These gradually and significantly decreases in the density yield coefficient showed that seeding rate efficiency, i.e. grain yield providing ability of seeding rate, significantly decreased with increasing seeding rates. On the other hand, R^2 values in linear and quadratic relationships between the seeding rate and the density yield coefficient were much higher than those between the seeding rate and the grain yield. These higher R^2 values indicated that the density yield coefficient could effectively explain variations caused by seeding rates, compared to the grain yield. In the literature, we could not find any research article studied on the density yield coefficient or traditional unit (at how fold). Sinclair (1998) only reported from Pliny (1971) that maximum yields were at 150-fold for the Byzacium plain, at 100-fold for Egypt and Babylon.

CONCLUSIONS

It was concluded that the R^2 values of linear and quadratic relationships between the seeding rate and the density yield coefficient were much higher than those between the seeding rate and the grain yield. These results indicated that the density yield coefficient in comparison with grain yield could be a more determinative component in explaining of variations caused by seeding rate. Therefore, in addition to yield and yield components, the density yield coefficient could have a potential to use in scientific researches related to seeding rates. It will also be very useful to test this trait in many different agro-ecological conditions with many different wheat varieties and seeding rates.

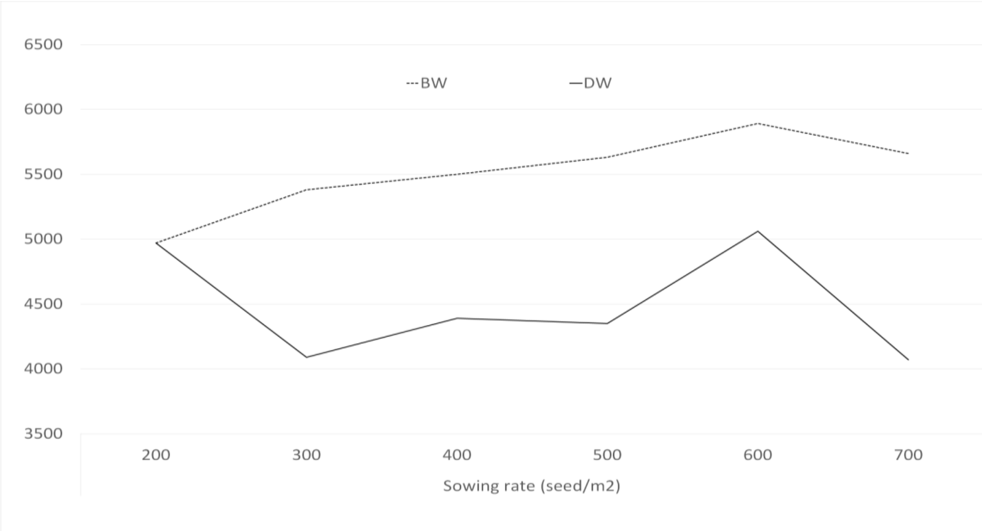

Figure 1. The grain yields of bread wheat (BW) and durum wheat (DW) by sowing rates

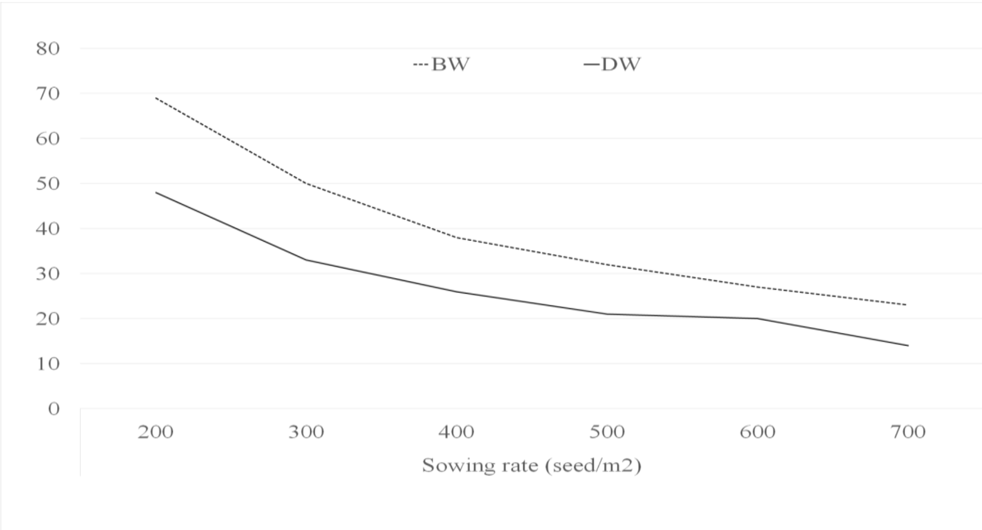

Figure 2. The density yield coefficients of bread wheat (BW) and durum wheat (DW) by sowing rates

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