Turkish Journal of Agricultural and Natural Sciences
Special Issue: 1, 2014

TÜRK
TARIM ve DOĞA BİLİMLERİ
DERGİSİ

TURKISH
JOURNAL of AGRICULTURAL
and NATURAL SCIENCES

www.turkjans.com

Stability Valuation of Some Mixtures between Foliar Fertilizers and Combined Herbicides for the Grain Yield of Durum Wheat

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Abstract

The research was conducted during 2010 - 2012 on pellic vertisol soil type. Under investigation was Bulgarian durum wheat cultivar Predel, which belongs to *Triticum durum var. valenciae* Desf. Factor A included years of investigation. Factor B included no treated check and 3 foliar fertilizers - Lactofol O - 8 l ha^{-1}, Terra-sorb - 3 l ha^{-1}, Humustim - 1 l ha^{-1}. Factor C included weeded no treated check and 3 combined herbicides – Axial one - 1 l ha^{-1}, Hussar max OD – 1 l ha^{-1}, Palace 75 WG - 250 g ha^{-1}. All of foliar fertilizers, herbicides and their tank-mixtures were treated in tillering stage of the durum wheat. There is antagonism of combined use by herbicide Hussar max with foliar fertilizers Lactofol and Humustim and by herbicide Palace with foliar fertilizer Lactofol. There is synergism by tank mixtures of herbicide Axial one with the three foliar fertilizers, by tank mixtures of herbicide Palace with foliar fertilizers Lactofol and Humustim, by tank mixtures of herbicide Hussar max with foliar fertilizer Terra-sorb. The highest grain yield is obtained by tank mixture Terra-sorb + Axial one. Tank mixtures of complex fertilizer Lactofol with herbicides Palace and Hussar max and tank mixture of organic fertilizer Humustim with herbicide Hussar max are the most unstable for grain yield. Tank mixtures of foliar fertilizer Terra-sorb with the three herbicides, of foliar fertilizer Humustim with herbicides Axial one and Palace and of foliar fertilizer Lactofol with herbicide Axial one are technological the most valuable. They combine high grain yield with high stability with relation to different years. Self-use of foliar fertilizers Lactofol, Terra-sorb and Humustim without herbicides have low estimate and do not be used in the durum wheat crops.

Keywords: durum wheat, foliar fertilizers, herbicides, grain yield, selectivity, stability

Introduction

The action of the herbicides depends on the the environmental conditions. For achieving the good herbicidal effect is necessary to know these conditions and their impact on different types of herbicides. The small amount of rainfall can result in decrease of the efficiency of herbicides, as subjected to water stress plant harder absorb them. The large amount of high intensity rainfall can wash herbicide from the place of their treatment. At temperatures lower than the optimum growth of the plant is delayed, which can lead to a reduction in the absorption of the herbicide, and its activity. Extremely high temperatures lead to evaporation of foliar herbicides, before they are absorbed by the plants (Kudsk and Mathiassen, 1995; Adkins et al.,. 1998; Hannan-Jones, 1998; Archambault et al., 2001; Hartzler and Battles, 2001; Misovic et al., 2001).

Foliar application of agricultural crops is an important reserve for the correction of soil fertilization. Advisability and effects of foliar application is the subject of research in the works of many authors (El-Naga, 1995; Phillips et al., 1999; Kyuchukova and Radeva, 2002; Nankova et al., 2004; Kertikov and Vasileva, 2007). Suitable for foliar application are modern (mineral) and organic (humic) fertilizers. They are characterized by an optimal balance of nutrients, high purity, contains the entire range of macronutrients and trace elements dissolve quickly and without residue. The market for such products offers a variety of brands, characterized by different physical and chemical formulation.

The purpose of this investigation was to establish the selectivity and stability of some foliar fertilizers, combined herbicides and their tank mixtures on the durum wheat by influence of different meteorological conditions.

Materials and Methods

The research was conducted during 2010 - 2012 on pellic vertisol soil type. It was carried out a three factor experiment as a block method in 4 repetitions, on a 20 m^2 harvesting area, after sunflower predecessor. Under investigation was Bulgarian durum wheat cultivar Predel, which belongs to *Triticum durum var. valenciae* Desf. Factor A included years of investigation. Factor B included no treated check and 3 foliar fertilizers - Lactofol O - 8 l ha^{-1}, Terra-sorb - 3 l ha^{-1}, Humustim - 1 l ha^{-1}. Factor C included weeded, no treated check and 3 combined herbicides – Axial one (pinoxaden + florasulam) - 1 l ha^{-1}, Hussar max OD (mesosulfuron + iodosulfuron) – 1 l ha^{-1}, Palace 75 WG (pyroxulam) - 250 g ha^{-1}.

Because of the low adhesion of the herbicide Palace it was used in addition with adjuvant Dassoil - 500 ml ha^{-1}. Complex fertilizers Lactofol O and Terra-sorb contain nitrogen in amide, ammonium and nitrate forms, easily absorbable phosphorus and potassium, trace elements, amino acids, physiologically active substances, and organic fertilizer Humustim - potassium salts of humic acids and fulvia acids. Both complex foliar fertilizers differ mainly in the nature of the complexing agent – in Lactofol O it is lactic acid, and in Terra-sorb it is ethylene-diamine-tetra-acetic acid (EDTA). All of foliar fertilizers, herbicides and their tank-mixtures were treated in tillering stage of the durum wheat and are applied in a working solution of 200 l ha^{-1}. Mixing was done in the tank on the sprayer.

Table 1. Grain yield, kg ha^{-1}

Variants		2010		2011		2012	
Foliar fertilizers	Herbicides	kg ha^{-1}	%	kg ha^{-1}	%	kg ha^{-1}	%
-	-	4444	100	3943	100	5004	100
	Axial one	4603	103.6	4190	106.3	5262	105.2
	Hussar max	4597	103.4	4180	106.0	5207	104.1
	Palace	4600	103.5	4133	104.8	5223	104.4
Lactofol O	-	4587	103.2	4033	102.3	5223	104.4
	Axial one	4707	105.9	4343	110.1	5405	108.0
	Hussar max	4377	98.5	4093	103.8	5317	106.3
	Palace	4730	106.4	3487	88.3	5571	111.3
Terra-sorb	-	4603	103.6	4007	101.6	5249	104.9
	Axial one	4770	107.3	4460	113.1	5590	111.7
	Hussar max	4623	104.0	4363	110.7	5327	106.5
	Palace	4723	106.3	4444	112.7	5498	109.9
Humustim	-	4593	103.4	4093	103.8	5222	1043
	Axial one	4716	106.1	4373	110.9	5502	110.0
	Hussar max	4353	98.0	4003	101.5	5299	105.9
	Palace	4707	105.9	4430	112.4	5557	111.1

LSD, kg ha^{-1}:

F.A	p≤0.5=70	p≤0.1=93	p≤0.01%=120
F.B	p≤0.5=81	p≤0.1=107	p≤0.01%=139
F.C	p≤0.5=82	p≤0.1=108	p≤0.01%=140
AxB	p≤0.5=140	p≤0.1=186	p≤0.01%=240
AxC	p≤0.5=141	p≤0.1=187	p≤0.01%=241
BxC	p≤0.5=162	p≤0.1=215	p≤0.01%=278
AxBxC	p≤0.5=281	p≤0.1=372	p≤0.01%=481

The selectivity of herbicides has been established through their influence on grain yield. The math processing of the data was done according to the method of analyses of

variance (Shanin 1977; Barov, 1982; Lidanski 1988). The stability of foliar fertilizers, herbicides and their tank mixtures for seed yield with relation to years was estimated using the stability variances σ_i^2 and S_i^2 of Shukla (1972), the ecovalence W_i of Wricke (1962) and the stability criterion YS_i of Kang (1993).

Results and Discussion

Experiment data show that the lowest grain yield is obtained by the untreated and weeded check (Table 1). The self-use of herbicides Axial one, Hussar max and Palace increases grain yield because the weeds are destroyed. The differences are small, due to superior efficacy of the three combined herbicides against grassy and broadleaved weeds. Differences in mean grain yields are from 10 kg ha^{-1} to 33 kg ha^{-1}.

The self-use of complex foliar fertilizers Lactofol and Terra-sorb and organic foliar fertilizer Humustim also increases grain yields because they stimulate the growth and development of durum wheat. The increases are 3.4 – 3.9 %. The increase by self-use of foliar fertilizers is less than the increase by combined herbicides because present weeds neutralize a part of positive effect.

It is established manifestations of antagonism by concurrent use of herbicide Hussar max with foliar fertilizers Lactofol and Humustim and by concurrent use of herbicide Palace with foliar fertilizer Lactofol. This antagonism leads to a decrease in grain yield in tank mixtures when they compared with self-use of the combined herbicides and fertilizers. Probable cause of antagonism between herbicides Hussar max and Palace by one hand and complex fertilizer Lactofol by other hand is the lactic acid, which is a complexing in this foliar fertilizer. There is not antagonism by tank mixtures of Hussar max and Palace with complex fertilizer Terra-sorb with complexing EDTA. Both complex foliar fertilizers differ mainly in the nature of the complexing agent - in Lactofol it is lactic acid, and in Terra-sorb it is ethylene-diamine-tetra-acetic acid (EDTA).

There is synergism in 2011 and 2012 by concurrent use of herbicide Axial one with the three foliar fertilizers, by concurrent use of herbicide Palace with foliar fertilizers Terasorb and Humustim and by concurrent use of herbicide Hussar max with foliar fertilizer Terasorb. Grain yield and herbicidal efficacy by these tank mixtures are higher in comparison with the self-use of the foliar fertilizers and combined herbicides. There is additive effect in 2010 by these tank mixtures. Grain yield is approximately equal to the aggregate effect of individual preparations. The reason for these differences is large differences in the weather during the three years of the investigation.

Table 2. Analysis of variance for grain yield

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean square
Total	143	421808	100	-
Tract of land	2	4670	1.1	2335.0**
Variants	47	388916	92.2	8274.8***
Factor A - Years	2	341674	80.9	170837.0***
Factor B – Foliar fertilizers	3	7572	1.8	2524.0***
Factor C – Herbicides	3	12906	3.1	4302.0***
AxB	6	5076	1.2	846.0*
AxC	6	3972	1.0	662.0*
BxC	9	6142	1.5	682.4*
AxBxC	18	11574	2.7	643.0**
Pooled error	94	18222	67	300.2

*p≤0.5 **p≤0.1 ***p≤0.01

Analysis of variance for grain yield (Table 2) shows that the years have the highest influence on grain yield – 80.9 % on the variants. The strength of influence of foliar fertilizers is 1.8 % and the strength of influence combined herbicides is 3.1 %. The reason is the large differences in the meteorological

conditions during the three years of investigation. The influence of years, foliar fertilizers and of herbicides is well proven at $p \leq 0.01$. There is a proven interaction between foliar fertilizers and meteorological conditions of years (AxB) – 1.2 %, between combined herbicides and meteorological conditions of years (BxC) – 1.0 % and between foliar fertilizers and combined herbicides (BxC) – 1.5 %. They are proven at $p \leq 0.5$. The interaction between three experiment factors (AxBxC) is higher – 1.5 % and it is proven at $p \leq 0.1$.

Based on proven foliar fertilizer x year interaction and combined herbicide x year interaction, it was evaluated stability parameters for each variant for grain yield of durum wheat with relation to years (Table 3). It was calculated the stability variances σ_i^2 and S_i^2 of Shukla, the ecovalence W_i of Wricke and the stability criterion YS_i of Kang.

Stability variances (σ_i^2 и S_i^2) of Shukla, which recorded respectively linear and nonlinear interactions, unidirectional evaluate the stability of the variants. These variants which showed lower values are considered to be more stable because they interact less with the environmental conditions. Negative values of the indicators σ_i^2 and S_i^2 are considered 0. At high values of either of the two parameters - σ_i^2 and S_i^2, the variant are regarded as unstable. At the ecovalence W_i of Wricke, the higher are the values of the index, the more unstable is the variant.

Table 3. Stability parameters for the variants for grain yield with relation to years

Variants		$\bar{x}$	σ_i^2	S_i^2	W_i	YS_i
Foliar fertilizers	Herbicides					
-	-	4464	1197.4*	1180.8*	1429.9	-5
	Axial one	4685	39.9	-33.7	154.2	9+
	Hussar max	4662	152.6	-18.2	351.5	8+
	Palace	4652	53.4	28.5	177.9	7+
Lactofol O	-	4614	68.4	198.7	204.1	4
	Axial one	4818	62.0	0.4	193.1	13+
	Hussar max	4596	186.3*	423.9	410.5	1
	Palace	4600	426.2*	534.4*	4830.4	0
Terra-sorb	-	4620	147.6	311.6	342.8	5
	Axial one	4934	115.6	284.5	286.8	18+
	Hussar max	4771	395.6	218.4	776.8	12+
	Palace	4888	201.2	295.9	436.6	16+
Humustim	-	4636	33.5	79.1	143.0	6
	Axial one	4864	39.8	127.1	154.2	15+
	Hussar max	4552	367.7*	419.7	728.0	1
	Palace	4898	326.8	659.5	656.3	17+

On this basis, using the first three parameters of stability, it is found that the most unstable are no treated check and tank mixture Lactofol + Palace. In these variants values of stability variance σ_i^2 and S_i^2 of Shukla and ecovalence W_i of Wricke are the highest and mathematically proven. The reason for this high instability is greater variation in grain yields during years of experience as weather conditions affect those most. At tank mixture of herbicide Hussar max with foliar fertilizers

Lactofol and Humustim, instability is a linear type - proven values σ_i^2, the values of S_i^2 are not proven. Other tank mixtures between combined herbicides and foliar fertilizers exhibit high stability because they interact poorly with the conditions of years.

To evaluate the complete efficacy of each tank mixture between foliar fertilizer and combined herbicide should be considered as its effect on grain yield of durum wheat and its stability - the reaction of wheat to this variant during the years. Valuable information about the value of technologic value of the variant give the stability criterion YS_i of Kang for simultaneous assessment of yield and stability, based on the reliability of the differences in yield and variance of interaction with the environment. The value of this criterion is experienced that using nonparametric methods and warranted statistical differences we get a summary assessment aligning variants in

descending order according to their economic value.

Generalized stability criterion YS_i of Kang, taking into accounts both the stability and value of yields gives a negative assessment only of weeded, untreated control, characterizing it as the most unstable and low yields. According to this criterion, the most valuable technology appears tank mixtures Terra-sorb + Axial one, Humustim + Palace, Terra-sorb + Palace, Humustim + Axial one, Lactofol + Axial one and Terra-sorb + Hussar max. These tank mixtures combine high levels of grain yield and high stability of this index during the years. From the viewpoint of technology for durum wheat growing, high rating also have self-use of herbicides Axial one, Hussar max and Palace. These herbicides combine relatively good grain yields with high stability during the years of the investigation. Variants with self-use of foliar fertilizers Lactofol, Terra-sorb and Humustim without a partner herbicide get low ratings and they to be avoided. In these variants, the positive effect of the foliar fertilizer use is neutralized by the negative effect of the present weeds, because of the absence of effective chemical control against them. Tank mixtures of complex fertilizer Lactofol with herbicides Palace and Hussar max and tank mixture of organic fertilizer Humustim with herbicide Hussar max get low ratings due to its high instability during the years of investigation.

Conclusion

There is antagonism of combined use by herbicide Hussar max with foliar fertilizers Lactofol and Humustim and by herbicide Palace with foliar fertilizer Lactofol.

There is synergism by tank mixtures of herbicide Axial one with the three foliar fertilizers, by tank mixtures of herbicide Palace with foliar fertilizers Lactofol and Humustim, by tank mixtures of herbicide Hussar max with foliar fertilizer Terra-sorb. The highest grain yield is obtained by tank mixture Terra-sorb + Axial one.

Tank mixtures of complex fertilizer Lactofol with herbicides Palace and Hussar max and tank mixture of organic fertilizer Humustim with herbicide Hussar max are the most unstable for grain yield.

Tank mixtures of foliar fertilizer Terra-sorb with the three herbicides, of foliar fertilizer Humustim with herbicides Axial one and Palace and of foliar fertilizer Lactofol with herbicide Axial one are technological the most valuable. They combine high grain yield with high stability with relation to different years.

Self-use of foliar fertilizers Lactofol, Terra-sorb and Humustim without herbicides have low estimate and do not be used in the durum wheat crops.

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