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STABILITY VALUATION OF SOME MIXTURES BETWEEN RETARDANTS AND ANTIBROADLEAVED 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. A field experiment was carried out with durum wheat cultivar Progress (Triticum durum var. leucurum Desf.). Factor A included the years of investigation. Factor B included no treated check and 3 retardants – Cycocel extra (chlormequat + cholinechloride) – 1.5 l/ha, Vivax (chlormequat + ethephon) – 1.7 l/ha, Terpal (ethephon + mepiquat) – 3 l/ha. Factor C included weeded no treated check and 4 antibroadleaved herbicides – Granstar 75 DF (tribenuron-methyl) – 20 g/ha, Granstar super 50 SG (tribenuron-methyl + tiphensulfuron-methyl) – 40 g/ha, Laren 20 SG (methsulfuron-methyl) – 30 g/ha, Ally max SG (methsulfuron-methyl + tribenuron-methyl) – 35 g/ha. All of retardants, antibroadleaved herbicides and their tank mixtures were treated in tillering stage of the durum wheat. The weak adhesion of Granstar, Granstar super, Laren and Ally max required its application with adjuvant Trend 90 – 0.1%. Herbicide Granstar super cannot be mixed with retardants containing chlormequat - Cycocel extra and Vivax. There is antagonism at mixtures of retardant Terpal with herbicides containing methsulfuron-methyl – Laren and Ally max. The lowest durum wheat grain yields are obtained by these tank mixtures. Tank mixtures of herbicide Granstar super with retardants Cycocel extra and Vivax and retardant Terpal with herbicides Laren and Ally max are the most unstable for grain yield. Tank mixtures of retardants Cycocel extra and Vivax with herbicides Ally max, Laren and Granstar and of retardant Terpal with herbicides Granstar super and Granstar are technological the most valuable. They combine high grain yield with high stability with relation to different years. Self-use of retardants Cycocel extra, Vivax and Terpal without herbicides have low estimate and do not be used in the durum wheat crops.

Keywords: *durum wheat, herbicides, retardants, selectivity, stability.*

INTRODUCTION

In the last years are used biologically active substances that increase plant resistance to lodging and contribute to more fully realize the productive potential of the durum wheat cultivars (Bhaskara et al., 1998; Sharma and Kumar, 1998; Panayotov and Stoeva, 2000; Delchev, 2004).

The studies showed that in wheat retardants based of chlormequat are more effective than those based of ethephon (Green et al., 1986; Kolev and Terziev, 1996).

Common and durum wheat are differ in their response to a different preparations (Rapparini et al., 1984, 1998; Woodward and Marshall, 1989).

There is evidence that the effectiveness of retardants depends on the biology of cultivars and mineral fertilization (Popov, 1966; Peev, 1977; Wiersma et al., 1986; Sharma and Kumar, 1998; Delchev, 2004a; Delchev, 2004b).

In modern agriculture the herbicides are an effective instrument of weed control in wheat.

Since their entry into agriculture to now be recommend the terms, the doses, treatment methods, and their influence on grain yield and grain quality in their self-use (Orth, 1965; O'Sullivan, 1980; Ahmed et al., 1993; Kudsk and Streibig, 2003; Delchev, 2008, Stoyanova and Georgiev, 2014, Styanova et al., 2015).

These studies do not provide enough light to questions about the impact of mixtures between different pesticides on durum wheat.

The purpose of this investigation was to establish the selectivity and stability of some retardants, antibroadleaved 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 factors field 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 Progress, which belongs to *Triticum durum var. leucurum*. Factor A included the years of investigation. Factor B included no treated check and 3 retardants – Cycocel extra (chlormequat + cholinechloride) – 1.5 l/ha, Vivax (chlormequat + ethephon) – 1.7 l/ha, Terpal (ethephon + mepiquat) – 3 l/ha. Factor C included weeded no treated check and 4 antibroadleaved herbicides – Granstar 75 DF (tribenuron-methyl) – 20 g/ha, Granstar super 50 SG (tribenuron-methyl + tiphensulfuron-methyl) – 40 g/ha, Laren 20 SG (methsulfuron-methyl) – 30 g/ha, Ally max SG (methsulfuron-methyl + tribenuron-methyl) – 35 g/ha.

The weak adhesion of Granstar, Granstar super, Laren and Ally max required its application with adjuvant Trend 90 – 0.1%. All of retardants, antibroadleaved herbicides and their tank mixtures were treated in tillering stage of the durum wheat with working solution 200 l/ha. Investigated herbicides have not antigraminaceous effect and the fight against graminaceous weeds in all variants was carried out with herbicide Traxos 045 EK in dose 1.2 l/ha.

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 retardants, herbicides and their tank mixtures for grain 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 DISCUSSIONS

Data for the influence of stimulators, antibroadleaved herbicides and their tank mixtures on grain yield (Table 1) show that the lower yield is obtained in untreated and weeded check. The separate uses of herbicides Granstar, Granstar super, Laren and Ally max increase grain yield, because destroy existing annual and perennial broadleaved weeds. The separate uses of retardants Cycocel extra, Vivax, and Terpal also increases yield because they stimulate the growth and development of durum wheat. The increase was less than its mixtures with herbicides, because available broadleaved weeds neutralize part of its positive effect. At all variants, grassy weeds are destroyed with antigrass herbicide Traxos which treated 10 days before the application of the relevant products.

There has been antagonism of combined use of herbicide Granstar super with retardants containing chlormequat - Cycocel extra and Vivax. Antagonism is biggest in 2011, when grain yields by tank mixtures Cycocel extra + Granstar super and Vivax + Granstar super are smaller and mathematically proven than grain yields by the other tank mixtures with 6 – 7%. Tank mixtures of herbicide Granstar super with retardants Cycocel extra and Vivax have not antagonism to grain yield during any of the years of investigation. Grain yields by these mixtures are higher than grain yields by the self-use of the preparations. This means that it is the antagonism between the active substance chlormequat containing in retardants Cycocel extra and Vivax by one hand and the active substance thifensulfuron - methyl containing in herbicide Granstar super by other hand. Herbicides Granstar, Laren and Ally max do not contain thifensulfuron- methyl and their mixtures with chlormequat from retardants Cycocel extra and Vivax have not antagonism. At combined use of retardant Terpal containing ethephon + mepiquat, but not containing chlormequat with herbicide Granstar super antagonism is also missing.

There has been antagonism of combined use of retardant Terpal with herbicides containing methsulfuron-methyl - Laren and Ally max. Antagonism is biggest in 2010, when grain yields by tank mixtures Terpal + Laren and Terpal + Ally max are smaller and mathematically proven than grain yields by the other tank mixtures with 3-4%.

Table 1. Influence on grain yield

Variants		2010		2011		2012	
Retardants	Herbicides	kg/ha	%	kg/ha	%	kg/ha	%
	-	3333	100	4040	100	4660	100
	Granstar	3600	108.0	4396	108.8	4982	106.9
-	Granstar super	3610	108.3	4424	109.5	5010	107.5
	Laren	3573	107.2	4412	109.2	4972	106.7
	Ally max	3610	108.3	4436	109.8	4982	106.9
	-	3560	106.8	4198	103.9	4930	105.8
	Granstar	3633	109.0	4460	110.4	5042	108.2
Cycocel extra	Granstar super	3660	109.8	4206	104.1	5033	108.0
	Laren	3633	109.0	4452	110.2	5089	109.2
	Ally max	3650	109.5	4488	111.1	5117	109.8
	-	3550	106.5	4189	103.7	4930	105.8
	Granstar	3643	109.3	4476	110.8	5070	108.8
Vivax	Granstar super	3656	109.7	4177	103.4	5042	108.2
	Laren	3650	109.5	4476	110.8	5103	109.5
	Ally max	3666	110.0	4464	110.5	5135	110.2
	-	3586	107.6	4202	104.0	4991	107.1
	Granstar	3626	108.8	4484	111.0	5093	109.3
Terpal	Granstar super	3620	108.6	4472	110.7	5126	110.0
	Laren	3423	102.7	4440	109.9	5070	108.8
	Ally max	3463	103.9	4444	110.0	5079	109.0

LSD, kg/ha:			
F.A	p≤5%=126	p≤1%=134	p≤0.1%=144
F.B	p≤5%=130	p≤1%=140	p≤0.1%=151
F.C	p≤5%=134	p≤1%=145	p≤0.1%=157
AxB	p≤5%=152	p≤1%=169	p≤0.1%=189
AxC	p≤5%=158	p≤1%=177	p≤0.1%=199
BxC	p≤5%=167	p≤1%=189	p≤0.1%=215
AxBxC	p≤5%=217	p≤1%=254	p≤0.1%=299

Tank mixtures of retardant Terpal with herbicides Granstar and Granstar super have not antagonism to grain yield during any of the years of investigation. Grain yields by these mixtures are higher than grain yields by the self-use of the preparations. This means that it is the antagonism between the active substance mepiquat containing in retardant Terpal by one hand and the active substance methsulfuron-methyl containing in herbicides Laren and Ally max by other hand. Retardants Cycocel extra and Vivax do not contain mepiquat and their mixtures with methsulfuron-methyl from herbicides Laren and Ally max have not antagonism. At combined use of herbicides Granstar and Granstar super with retardants Cycocel extra and Vivax containing respectively chlormequat + cholinechloride and chlormequat + ethephon, but not containing mepiquat antagonism is also missing.

Analysis of variance for grain yield (Table 2) shows that the years have the highest influence on grain yield – 81.7% on the variants. The strength of influence of retardants is 1.3% and the strength of influence antibroadleaved herbicides is 2.4%.

The reason is the large differences in the meteorological conditions during the three years of investigation. The influence of years and of herbicides is very well proven at $p \leq 0.01$. The influence of retardants is well proven at $p \leq 0.1$. There is a well proven interaction between retardants and meteorological conditions of years (AxB) – 1.2%, between herbicides and meteorological conditions of years (AxC) – 1.4% and between retardants and antibroadleaved herbicides (BxC) – 1.6%. They are proven at $p \leq 0.1$. The interaction between three experiment factors (AxBxC) is not proven.

Based on proven retardant x year interaction and antibroadleaved 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.

Table 2. Analysis of variance for grain yield

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean squares
Total	179	714244	100	-
Tract of land	2	66616	9.4	33308.0***
Variants	59	641484	89.8	10872.6***
Factor A – Years	2	619772	81.7	309886.0***
Factor B – Retardants	3	1908	1.3	636.0**
Factor C – Herbicides	4	9844	2.4	2461.0***
AxB	6	1700	1.2	2830.3**
AxC	8	2836	1.4	354.5**
BxC	12	4012	1.6	334.3**
AxBxC	24	1412	0.2	58.8
Pooled error	118	6144	0.8	521

*p≤5% **p≤1% ***p≤0.1%

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

Variants						
Retardants	Herbicides	$\bar{x}$	σ_i^2	S_i^2	W_i	YS_i
	-	4011	93.2	-7.5	183.4	-5
	Granstar	4326	36.0	34.4	80.4	10+
-	Granstar super	4348	32.1	52.5	73.5	13+
	Laren	4319	69.6	127.8	140.9	9+
	Ally max	4343	92.9	133.7	183.0	12+
	-	4229	158.6	237.3*	301.1	1
	Granstar	4378	38.1	73.3	84.3	14+
Cycocel extra	Granstar super	4300	478.5**	871.4**	877.0	-3
	Laren	4391	4.3	6.2	23.6	16+
	Ally max	4418	19.8	26.4	51.3	21+
	-	4223	158.3	258.5*	300.7	0
	Granstar	4396	28.9	63.2	67.7	17+
Vivax	Granstar super	4292	619.0**	1177.9**	1129.8	-4
	Laren	4410	9.7	18.7	33.3	20+
	Ally max	4422	0.7	-11.6	16.8	22+
	-	4260	203.4	467.2**	453.7	0
	Granstar	4401	43.4	71.9	93.5	18+
Terpal	Granstar super	4406	48.1	14.4	102.2	19+
	Laren	4311	556.7**	321.8*	1017.7	-2
	Ally max	4329	400.1**	225.7*	735.8	-1

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.

On this basis, using the first three parameters of stability, it is found that the most unstable are tank mixture of herbicide Granstar super with retardants Cycocel extra and Vivax and of retardant Terpal with herbicides Laren and Ally max. Self-use of retardants Cycocel extra, Vivax and Terpal without herbicides are unstable too. 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 Granstar super with retardants Cycocel extra and Vivax and thank mixtures of retardant Terpal with herbicides Laren and Ally max, instability is linear and nonlinear types - proven values of σ_i^2 and S_i^2. At retardants

Cycocel extra, Vivax and Terpal without herbicides instability is nonlinear type - proven values of S_i^2, the values of σ_i^2 are not proven. Other tank mixtures between retardants and antibroadleaved herbicides exhibit high stability because they interact poorly with the conditions of years.

To evaluate the complete efficacy of each tank mixture between retardant and antibroadleaved 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 of weeded, untreated control, tank mixtures Cycocel extra + Granstar super, Vivax + Granstar super, Terpal + Laren and Terpal + Ally max, characterizing them as the most unstable and low yields. According to this criterion, the most valuable technology appears tank mixtures Vivax + Ally max, Cycocel extra + Ally max, Vivax + Laren, Terpal + Granstar super, Terpal + Granstar, Vivax + Granstar, Cycocel extra + Laren and Cycocel extra + Granstar. 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 Granstar, Granstar super, Laren and Ally max. These herbicides combine relatively good grain yields with high stability during the years of the investigation. Variants with self-use of retardants Cycocel extra, Vivax and Terpal without a partner herbicide get low ratings and they to be avoided. In these variants, the positive effect of the retardant use is neutralized by the negative effect of the present weeds, because of the absence of effective chemical control against them.

CONCLUSIONS

Herbicide Granstar super cannot be mixed with retardants containing chlormequat - Cycocel extra and Vivax. There is antagonism at mixtures of retardant Terpal with herbicides containing methsulfuron-methyl – Laren and Ally max. The lowest durum wheat grain yields are obtained by these tank mixtures.

Tank mixtures of herbicide Granstar super with retardants Cycocel extra and Vivax and retardant Terpal with herbicides Laren and Ally max are the most unstable for grain yield.

Tank mixtures of retardants Cycocel extra and Vivax with herbicides Ally max, Laren and Granstar and of retardant Terpal with herbicides Granstar super and Granstar are technological the most valuable. They combine high grain yield with high stability with relation to different years.

Self-use of retardants Cycocel extra, Vivax and Terpal without herbicides have low estimate and do not be used in the durum wheat crops.

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