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STABILITY ESTIMATION OF SOME MIXTURES BETWEEN RETARDANTS AND ANTICEREAL HERBICIDES FOR GRAIN YIELD OF DURUM WHEAT

Gr. DELCHEV and A. STOYANOVA
Trakia University, Faculty of Agriculture, BG – 6000 Stara Zagora, Bulgaria

Abstract

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The research was conducted during 2010-2012 on pellic vertisol soil type. 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 control and 3 retardants – Stabilan (chlormequat) – 2 $l.ha^{-1}$, Flordimex extra (ethephon) – 750 $ml.ha^{-1}$, Terpal (ethephon + mepiquat) – 3 $l.ha^{-1}$. Factor C included weeded no treated control and 3 anticereal herbicides – Scorpio super 100 EC (phenoxaprop-ethyl) – 700 $ml.ha^{-1}$, Grasp 25 SC (tralkoxidym) – 1.2 $l.ha^{-1}$, Topik 080 EC (clodinafop) – 450 $ml.ha^{-1}$. The weak adhesion of Grasp required its application with adjuvant Atplus – 1.2 $l.ha^{-1}$. Investigated herbicides have not antibroadleaved effect and control of broadleaved weeds in all variants was done with herbicide Secator OD in dose 100 $ml.ha^{-1}$. All of retardants, herbicides and their tank-mixtures were treated in tillering stage of the durum wheat.

The most increase of grain yield is obtained by combined use of retardant Terpal with herbicide Grasp, of retardant Flordimex extra with herbicides Grasp and Scorpio super and of retardant Stabilan with herbicides Grasp and Topik. Tank mixtures of Scorpio super with Stabilan and Terpal and tank mixtures of Topik with Flordimex extra and Terpal are the most unstable for grain yield. Tank mixtures Terpal + Grasp, Flordimex extra + Scorpio super, Stabilan + Grasp, Flordimex extra + Grasp and Stabilan + Topik are technological the most valuable. They combine high grain yield with high stability with relation to different years. Application of retardants Stabilan, Flordimex extra and Terpal without herbicides have low estimate and could not be used in the durum wheat crops.

Key words: durum wheat, retardants, herbicides, grain yield, selectivity, stability

Introduction

Growth regulators, properly selected and used an appropriate level of fertilization, increase grain yield and grain quality, where traditional methods and tools are less effective or nearly exhausted their possibilities. Is the emerging widespread use of herbicides and retardants to regulate growth and development of field crops and their weed associations in XXI century will be the main practice of obtaining more qualitative plant production (Sengalevich et al., 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; 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,b).

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

*E-mail: toni_1219@abv.bg

Material and Methods

The research was conducted during 2010-2012 on pellic vertisol soil type. Under investigation was Bulgarian durum wheat cultivar Progress, which belongs to *Triticum durum* var. *leucurum*. 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. Factor A included the years of investigation. Factor B included no treated control and 3 retardants, which are shown in Table 1. Factor C included weeded no treated control and 3 anticereal herbicides, which are shown in Table 2.

Table 1
Investigated retardants (Factor B)

Retardants	Active substance	Doses, $l.ha^{-1}$
Control – no treated	–	–
Stabilan	chlormequat	2
Flordimex extra	ethephon	0.75
Terpal	ethephon + mepiquat	3

Table 2
Investigated herbicides (Factor C)

Herbicides	Active substance	Doses, $l.ha^{-1}$
Control – weeded	–	–
Scorpio super 100 EC	phenoxaprop-ethyl	0.7
Grasp 25 SC	tralkoxidym	1.2
Topik 080 EC	clodinafop	0.45

The weak adhesion of herbicide Grasp required its application with adjuvant Atplus – 1.2 $l.ha^{-1}$. All of retardants, herbicides and their tank-mixtures were treated in tillering stage of the durum wheat with working solution 200 $l.ha^{-1}$. Mixing was done in the spraying tank. Due to investigate herbicides have not antibroadleaved effect; the control of broadleaved weeds in all variants was done with herbicide Secator OD at dose 0.1 $l.ha^{-1}$.

It is made a statistical evaluation for characterization of the representativeness and significance influence of the grain yield by analysis of variance and parametric criterion F of Fisher (Shanin, 1977; Barov, 1982). For calculating the analysis of variance is used the program ANOVA123 (Lidanski, 1988). The parameters of stability for grain yield are calculated. The variances of stability σ_i^2 and S_i^2 (Shukla, 1972) and ecovalence W_i (Wricke, 1962) show what part of the variation related to the interaction between the preparations and years is due to the concrete variant.

By the criterion for stability (YS_i) of Kang (1993) is presented the value of each variant by simultaneously reading of the worth of the indicator and the stability of the variant. The value of this criterion is that using nonparametric methods and statistical significance of the differences we receive a generalized evaluation arranging the variants in descending order according to their economic value. To calculate these parameters are used the program STABLE of Louisiana State University Agricultural Center, Baton Rouge, USA (1993).

Results and Discussion

Experiment data show that the lowest grain yield is obtained by the untreated and weeded control (Table 3). The application of herbicides Scorpio super, Grasp and Topik increases grain yield because the weeds are destroyed. The application of retardants Stabilan, Flordimex extra and Terpal also increases grain yields because they stimulate the growth and development of durum wheat, but the increase is less than in their mixtures with herbicides because present weeds neutralize a part of positive effect. Variant treated with retardant Flordimex extra, give the poor increase in grain yield compared to other retardants included in the experiment - 154 $kg.ha^{-1}$ or 3.3% more than the untreated check. These results confirm our previous studies (Delchev, 2004a,b) that during drought ethephon based retardants, besides short of the plant height and also decrease grain yield of the durum wheat.

It was found that herbicide Scorpio super not be mixed with retardants containing chlormequat and mepiquat. Tank-mixtures of this herbicide with retardants Stabilan and Terpal in some years cause reduction in yield. In tank mixtures Scorpio super + Stabilan in 2011 and Scorpio super + Terpal in 2010 grain yield is lower even than in the untreated check by 6.5% and 5.3%. During the years of investigation in these tank mixes have also have antagonism, but in a much lesser degree. Grain yield is proved higher than control but unproven higher than in their self-application. In tank mixture of herbicide Scorpio super with retardant Flordimex extra containing only ethephon, there is an additive effect. In this tank mixture Scorpio super and Flordimex extra complement their action.

Herbicide Topik cannot be used with retardants containing ethephon or mepiquat. During drought conditions as in 2010 and 2011 there is an antagonism leading to a reduction in grain yield at tank mixtures of herbicide Topik with retardants Flordimex extra and Terpal. During cool and wet conditions after treatment period, as in 2012 there is not phytotoxicity. Antagonism at tank mixtures of herbicides Scorpio super and Topic with retardants is lead mainly to grain yield decreasing and less reduction in the herbicidal effect. At tank mixture Topik with Flordimex extra not reported manifestations of antagonism.

Table 3
Influence of retardants and herbicides on grain yield, kg.ha^{-1}

Variants		2010		2011		2012	
Retardants	Herbicides	kg.ha^{-1}	%	kg.ha^{-1}	%	kg.ha^{-1}	%
without retardant	without herbicide	3170	100	4004	100	4666	100
	Scorpio super	3377	106.5	4297	107.3	5077	108.8
	Grasp	3403	107.4	4350	108.6	4983	106.8
	Topik	3420	107.9	4343	108.5	5061	108.5
Stabilan	without herbicide	3390	106.9	4137	103.3	4943	105.9
	Scorpio super	3317	104.6	3743	93.5	4877	104.5
	Grasp	3437	108.4	4317	107.8	5135	110.1
	Topik	3410	107.6	4230	105.6	5143	110.2
Flordimex extra	without herbicide	3380	106.6	4100	102.4	4820	103.3
	Scorpio super	3437	108.4	4467	111.6	5120	109.7
	Grasp	3470	109.5	4343	108.5	5388	115.4
	Topik	3447	108.7	3963	99.0	5066	108.6
Terpal	without herbicide	3410	107.6	416,1	103.9	4992	107.0
	Scorpio super	3003	94.7	4467	111.6	5034	107.9
	Grasp	3420	107.9	4503	112.5	5119	109.7
	Topik	2893	91.3	4523	113.0	5104	109.4

Herbicide Grasp show good miscibility with retardants Stabilan, Flordimex extra and Terpal. Their tank mixtures there are an additive effect in the three years of the investigation. Synergism is reported only in certain years with a favorable combination of temperature and rainfall.

Analysis of variance for grain yield (Table 4) shows that the years have the highest influence on grain yield – 87.1% on the variants. It is determined by the unequal response of variants to changing in environmental conditions. The reason is the large differences in the meteorological conditions during the three years of investigation. The strength of influence of retardants is 0.2% and the strength of influence anticereal herbicides is 2.2%. The influence of years and of herbicides is well proven at $p \leq 0.01$. Influence of retardants is not proven. There is an interaction between retardants and meteorological conditions of years (AxB) – 1.5%, between retardants and anticereal herbicides (BxC) – 1.4% and between three experiment factors (AxBxC) – 1.5%. They are proven at $p \leq 0.01$. Interaction of anticereal herbicides with meteorological conditions of years (AxC) is 1.5%. It is proven at $p \leq 0.5$.

Based on proven retardant x year interaction and anticereal herbicide x year interaction, it was evaluated stability parameters for each variant for grain yield of durum wheat with relation to years (Table 5). 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 4

Analysis of variance for grain yield

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean square
Total	143	776648	100	-
Field blocks	2	21960	2,8	10980.0***
Variants	47	737658	95.0	15694.9***
Factor A – Years	2	692068	87.1	346034.0***
Factor B – Retardants	3	1412	1,2	470.7
Factor C – Herbicides	3	9310	2,2	3103.3***
A×B	6	10226	1,5	1704.3***
A×C	6	3116	1,1	519.3*
B×C	9	10249	1,4	1136.7***
A×B×C	18	11278	1,5	626.6***
Pooled error	94	17030	2,2	181.2

* $p \leq 0.5$; ** $p \leq 0.1$; *** $p \leq 0.01$

Table 5
Stability parameters for the variants for grain yield with relation to years

Variants		$\bar{X}$	σ_i^2	S_i^2	Wi	YSi
Retardants	Herbicides					
without retardant	without herbicide	3947	292.50	-48.50	614.50	-2
	Scorpio super	4250	-57.90	-69.50	1.50	11+
	Grasp	4246	160.80	153.90	384.10	10+
	Topik	4275	-13.60	-29.60	79.00	13+
Stabilan	without herbicide	4157	213.50	98.90	476.30	3
	Scorpio super	3979	2078.8**	3783.5**	3740.60	-9
	Grasp	4296	-47.70	-48.90	19.30	14+
	Topik	4261	87.30	204.40	255.40	12+
Flordimex extra	without herbicide	4100	549.20	-7.70	1063.80	1
	Scorpio super	4341	125.70	297.10	322.80	16+
	Grasp	4400	612.2*	485.10	1174.00	14+
	Topik	4159	1437.1**	2766.9**	2617.70	-4
Terpal	without herbicide	4188	172.60	147.40	404.70	7
	Scorpio super	4168	2607.6**	3125.3**	4666.00	-3
	Grasp	4347	277.50	599.50	588.30	17+
	Topik	4174	4654.9**	4420.9**	8248.80	-2

Stability variances (σ_i^2 and 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 mixtures of herbicide Scorpio super with retardants Stabilan and Terpal, followed by tank mixtures of herbicide Topik with retardants Flordimex extra and Terpal. 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 Grasp + Flordimex extra, instability is a linear type – proven values σ_i^2, the values of S_i^2 are not proven. Other tank mixtures between retardants and anticereal 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 anticereal 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 and tank mixtures Stabilan + Scorpio super, Flordimex extra + Topik, Terpal + Scorpio super and Terpal + Topik, characterizing it as the most unstable and low yields. According to this criterion, the most valuable technology appears tank mixtures Terpal + Grasp, Flordimex extra + Scorpio super, Stabilan + Grasp, Flordimex extra + Grasp and Stabilan + Topik. 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 application of herbicides Scorpio super, Grasp and Topik. These anticereal herbicides combine relatively good grain yields with high stability during the years of the investigation. Variants with application of retardants Stabilan, Flordimex extra and Terpal without a partner herbicide get low ratings and them 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

The most increase of grain yield is obtained by combined use of retardant Terpal with herbicide Grasp, of retardant Flordimex extra with herbicides Grasp and Scorpio super and of retardant Stabilan with herbicides Grasp and Topik.

Tank mixtures of Scorpio super with Stabilan and Terpal and tank mixtures of Topik with Flordimex extra and Terpal are the most unstable for grain yield.

Tank mixtures Terpal + Grasp, Flordimex extra + Scorpio super, Stabilan + Grasp, Flordimex extra + Grasp and Stabilan + Topik are technological the most valuable. They combine high grain yield with high stability with relation to different years.

Application of retardants Stabilan, Flordimex extra and Terpal without herbicides have low estimate and could not be used in the durum wheat crops.

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