STABILITY VALUATION OF SOME MIXTURES BETWEEN STIMULATORS AND COMBINED HERBICIDES FOR THE GRAIN YIELD OF DURUM WHEAT

Grozi Delchev
Trakia University, Faculty of Agriculture, 6000, Stara Zagora, Bulgaria
e-mail: delchevgd@dir.bg

ABSTRACT

The research was conducted during 2010 - 2012 on pellic vertisol soil type. Under investigation was Bulgarian durum wheat cultivar Elbrus, which belongs to *Triticum durum var. valenciae*. Factor A included the years of investigation. Factor B included no treated check and 4 stimulators – Trisalvit (phenoxy acid derivatives, quaternary ammonium salts, trace elements) - 300 ml/ha, Salvit (synthetic auxins, trace elements, vitamins, surface active substances) - 500 ml/ha, Napsil (chlorofenoxyacetic acid derivatives, naftilacetic acid, phtalamine acid, chlorochlorine chloride, folic acid, trace elements) - 500 ml/ha, Cemofol (methilphtalamine acid derivatives, chlorochlorine chloride, folic acid, salicylic acid, trace elements, surface active substance) - 700 ml/ha. Factor C included weeded, no treated check and 3 combined herbicides – Palace 75 WG (pyroxulam) - 250 g/ha, Axial one (pinoxaden + florasulam) - 1 l/ha, Pacifica WG (mesosulfuron-methyl + iodosulfuron-methyl) - 350 g/ha. Because of the low adhesion of the herbicides Palace and Pacifica they were used in addition with adjuvants respectively Dassoil - 500 ml/ha and Biopower - 700 ml/ha. All of stimulators, 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. Mixing was done in the tank on the sprayer.

There is antagonism of combined use by herbicide Pacifica with stimulators Trisalvit and Salvit. There is not antagonism by tank mixtures Napsil + Pacifica and Cemofol + Pacifica. There is additive effect by tank mixtures of stimulators Trisalvit, Salvit, Napsil and Cemofol with combined herbicides Palace, Axial one and Pacifica. The highest grain yield is obtained by tank mixture Trisalvit + Axial one. Tank mixtures of herbicide Palace with stimulator Napsil and herbicide Pacifica with stimulators Trisalvit and Salvit are the most unstable for grain yield. Tank mixtures of herbicide Axial one with stimulators Trisalvit, Napsil, Cemofol and Salvit and of herbicide Palace with stimulators Cemofol and Salvit are technological the most valuable. They combine high grain yield with high stability with relation to different years. Alone application of stimulators Trisalvit, Salvit, Napsil and Cemofol without herbicides have low estimate and do not be used in the durum wheat crops.

Key words: *durum wheat, stimulators, herbicides, grain yield, selectivity, stability*

INTRODUCTION

In connection with the increased demands for environmental safety in the use of pesticides in modern agriculture in recent years emerged as a relevant question about the influence of herbicides and their mixtures on growth, development, yield and quality of crops. In modern grain production herbicides are an effective means of weed control in wheat. In case of use it is necessary to know not only their efficacy against weeds, but their specific effect on the wheat plants (Martin et al. 2001; Domoradzki and Rola, 2002; Senior and Dale, 2002). In the research works very often in parallel with the verification of biological efficacy of the herbicides examining also and their influence on grain yield and grain quality (Hannan-Jones, 1998; Archambault et al., 2001; Hartzler and Battles, 2001).

Growth regulators properly selected and used the appropriate level of fertilization, increase yield and quality of the obtained production when classical methods and tools are less effective or nearly are exhausted their possibilities (Vildflush and Gurban, 1999; Delchev, 2003). In the scientific literature there are data indicative that common wheat and durum wheat respond differently to treatment with the same preparations (Rapparini et al., 1984; Pomati, 1987).

The purpose of the investigation was to establish the selectivity and stability of some stimulators, 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. Under investigation was Bulgarian durum wheat cultivar Elbrus, which belongs to *Triticum durum var. valenciae*. It was carried out a three factor field experiment. Factor A included the years of investigation. Factor B included no treated check and 4 stimulators – Trisalvit (phenoxy acid derivatives, quaternary ammonium salts, trace elements) - 300 ml/ha, Salvit (synthetic auxins, trace elements, vitamins, surface active substances) - 500 ml/ha, Napsil (chlorofenoxyacetic acid derivatives, naftilacetic acid, phtalamine acid, chlorochlorine chloride, folic acid, trace elements) - 500 ml/ha, Cemofol (methilphtalamine acid derivatives, chlorochlorine chloride, folic acid, salicylic acid, trace elements, surface active substance) - 700 ml/ha. Factor C included weeded, no treated check and 3 combined herbicides – Palace 75 WG (pyroxulam) - 250 g/ha, Axial one (pinoxaden + florasulam) - 1 l/ha, Pacifica WG (mesosulfuron-methyl + iodosulfuron-methyl) - 350 g/ha.

Because of the low adhesion of the herbicides Palace and Pacifica they were used in addition with adjuvants respectively Dassoil - 500 ml/ha and Biopower - 700 ml/ha. All of stimulators, 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. Mixing was done in the tank on the sprayer.

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 herbicides and herbicide combinations 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

The obtained data show that the lowest grain yield is obtained in weeded and untreated check (Table 1). At alone application of herbicides Palace, Axial one and Pacifica grain yield increases because the weeds are destroyed. The highest grain yield is obtained by herbicide Palace – 6.9 %. The reason for the small increase of the yield is that the Palace is less effective against some annual broadleaved weeds and is ineffective against *Convolvulus arvensis* and *Papaver rhoes*.

Alone application of stimulators Trisalvit, Salvit, Napsil and Cemofol increases grain yield because they stimulate the growth and development of durum wheat. The increase ranged from 5.5 % by Trisalvit to 6.4 % by Cemofol. The alone application of stimulators lead to less increase than alone application of combined herbicides due to available weeds neutralize some of the positive effects.

It is established manifestations of antagonism by concurrent use of combined herbicide Pacifica with stimulators Trisalvit and Salvit in 2010 and 2011. In 2012 it is not established manifestations of antagonism. There are not antagonisms by tank mixtures Napsil + Pacifica and Cemofol + Pacifica. The mixing of stimulators Trisalvit, Salvit, Napsil and Cemofol with the other two combined herbicides Palace and Axial one not lead to antagonism. They have an additive effect. At these tank mixtures grain yield and herbicide effect is equal to the aggregate effect of these stimulators and combined herbicides. The increase of grain yield is the bigger in tank mixture Trisalvit + Axial one. The increase is 13.7 % or 656 kg/ha average for the investigated period.

Analysis of variance for grain yield (Table 2) shows that the years have the highest influence on grain yield – 36.8 % on the variants. The strength of influence of stimulators is 8.6 % and the strength of influence combined herbicides is 14.8 %. The reason is the large differences in the meteorological conditions during the three years of investigation. The influence of years, stimulators and of herbicides is very well proven at $p \leq 0.01$. There is an interaction between herbicides and meteorological conditions of years (AxC) – 1.6 % and between stimulators and combined herbicides (BxC) – 2.2 %. They are well proven at $p \leq 0.1$. Interaction of stimulators with

meteorological conditions of years (AxB) is poor - 1.3 %. It is proven at $p \leq 0.5$. Interaction between three experiment factors (AxBxC) is not proven.

Table 1: Grain yield, kg/da

Variants		2010		2011		2012	
Stimulators	Herbicides	kg/ha	%	kg/ha	%	kg/ha	%
-	-	4800	100	5005	100	4555	100
	Palace	5117	106,0	5395	107,8	4846	106,4
	Axial one	5126	106,8	5420	108,3	4883	107,2
	Pacifica	5107	106,4	5405	108,0	4883	107,2
Trisalvit	-	5030	104,8	5330	106,5	4787	105,1
	Palace	5424	113,1	5616	112,2	5074	111,4
	Axial one	5472	114,0	5705	114,0	5152	113,1
	Pacifica	5174	107,8	5355	107,0	5033	110,5
Salvit	-	5021	104,6	5345	106,8	4806	105,5
	Palace	5462	113,8	5561	111,1	5138	112,8
	Axial one	5477	114,1	5581	111,5	5129	112,6
	Pacifica	5146	107,2	5375	107,4	5011	110,0
Napsil	-	5040	105,0	5355	107,0	4815	105,7
	Palace	5318	110,8	5666	113,2	5184	113,8
	Axial one	5429	113,1	5646	112,9	5147	113,0
	Pacifica	5270	109,8	5561	111,1	5106	112,1
Cemofol	-	5050	105,2	5385	107,6	4842	106,3
	Palace	5424	113,0	5666	113,2	5120	112,4
	Axial one	5443	113,4	5656	113,0	5102	112,0
	Pacifica	5285	110,1	5571	111,3	5124	112,5

LSD, kg/da:

F.A	p≤5%=125	p≤1%=134	p≤0,1%=143
F.B	p≤5%=133	p≤1%=143	p≤0,1%=156
F.C	p≤5%=134	p≤1%=144	p≤0,1%=157
AxB	p≤5%=157	p≤1%=175	p≤0,1%=197
AxC	p≤5%=158	p≤1%=176	p≤0,1%=198
BxC	p≤5%=174	p≤1%=197	p≤0,1%=225
AxBxC	p≤5%=227	p≤1%=268	p≤0,1%=317

Based on proven stimulator x year interaction and combined herbicide x year interaction, it was evaluated stability parameters for each tank mixture between stimulator and herbicide 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 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.

Table 2: Analysis of variance for grain yield

Source of variation	Degrees of freedom	Sum of squares	Influence of factor, %	Mean square
Total	179	231460	100	-
Tract of land	2	69128	29,8	34564,0***
Variants	59	153092	66,2	2068,8***
Factor A - Years	2	91932	36,8	45966,0***
Factor B - Stimulators	3	19872	8,6	4968,0***
Factor C - Herbicides	4	34236	14,8	8559,0***
AxB	6	800	1,3	100,0*
AxC	8	1380	1,6	172,5**
BxC	12	2720	2,2	170,0**
AxBxC	24	1152	0,9	67,3
Pooled error	118	9240	4,0	62,4

*p≤0.5 **p≤0.1 ***p≤0.01

On this basis, using the first three parameters of stability, it is found that the most unstable are tank mixture of herbicide Palace with stimulatur Napsil and tank mixtures of herbicide Pacifica with stimulators Trisalvit and Salvit. 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 Napsil + Palace there is instability from linear and nonlinear type - proven values σ_i^2 and S_i^2. At tank mixtures Trisalvit + Pacifica and Salvit + Pacifica, instability is a linear type - proven values σ_i^2, the values of S_i^2 are not proven. Other tank mixtures between stimulators and combined herbicides exhibit high stability because they interact poorly with the conditions of years.

To evaluate the complete efficacy of each tank mixture between stimulator 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 of untreated control, characterizing it as the most unstable and low yields. According to this criterion, the most valuable technology appears tank mixtures Trisalvit + Axial one, Napsil + Axial one, Cemofol + Palace, Cemofol + Axial one, Salvit + Axial one and Salvit + Palace. 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 ratings also have tank mixtures Napsil + Palace, Cemofol + Pacifica and Napsil + Pacifica. They combine

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
Stimulators	Herbicides					
-	-	4787	13,9	-1,1	32,8	-2
	Palace	5119	21,5	-1,1	46,9	5
	Axial one	5143	22,9	21,1	49,4	7
	Pacifica	5132	24,2	40,6	51,9	6
Trisalvit	-	5049	29,6	25,9	61,8	0
	Palace	5372	64,3	97,9	125,7	21+
	Axial one	5443	37,3	21,2	76,0	28+
	Pacifica	5187	247,8*	9,4	463,3	6
Salvit	-	5057	54,6	82,7	107,9	0
	Palace	5387	156,4	273,6	295,1	22+
	Axial one	5396	151,9	280,8*	296,8	23+
	Pacifica	5177	168,4*	56,4	317,1	9
Napsil	-	5070	43,4	56,5	87,2	2
	Palace	5412	287,9**	467,1**	537,1	19+
	Axial one	5407	2,6	8,3	12,2	26+
	Pacifica	5312	64,7	104,9	126,3	17+
Cemofol	-	5092	70,8	109,4	137,6	3
	Palace	5403	23,2	6,0	49,9	25+
	Axial one	5403	58,6	61,0	115,2	25+
	Pacifica	5327	68,8	101,5	133,9	19+

relatively good grain yields with high stability during the years of the investigation. Alone application of herbicides Palace, Axial one and Pacifica and combinations of Pacifica with Trisalvit and Salvit get low ratings. Alone application of stimulators Trisalvit, Salvit, Napsil and Cemofol without a partner herbicide get low ratings and them to be avoided. In these variants, the positive effect of the stimulator use is neutralized by the negative effect of the present weeds, because of the absence of effective chemical control against them.

CONCLUSION

There is antagonism of combined use by herbicide Pacifica with stimulators Trisalvit and Salvit. There is not antagonism by tank mixtures Napsil + Pacifica and Cemofol + Pacifica.

There is additive effect by tank mixtures of stimulators Trisalvit, Salvit, Napsil and Cemofol with combined herbicides Palace, Axial one and Pacifica. The highest grain yield is obtained by

tank mixture Trisalvit + Axial one.

Tank mixtures of herbicide Palace with stimulator Napsil and herbicide Pacifica with stimulators Trisalvit and Salvit are the most unstable for grain yield.

Tank mixtures of herbicide Axial one with stimulators Trisalvit, Napsil, Cemofol and Salvit and of herbicide Palace with stimulators Cemofol and Salvit are technological the most valuable. They combine high grain yield with high stability with relation to different years.

Alone application of stimulators Trisalvit, Salvit, Napsil and Cemofol without herbicides have low estimate and do not be used in the durum wheat crops.

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