STUDY ON THE IDENTIFICATION OF HERBICIDES WITH HIGH SELECTIVITY TO ENSURE CULTURAL HYGIENE IN GRAIN SORGHUM CROPS

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ABSTRACT

The integrated management of weeds uses a combination of biological, cultural, mechanical and chemical measures to combat the weeds in order to maximize the economic profits. Integrated management strategies for cultural hygiene are not sufficiently developed for selective herbicides in order to combat weeds for Sorghum bicolor (L.).

The efficacy of the applied herbicides was tested using the Abbott's formula, and the most effective in controlling weeds in the grain sorghum culture for the Caracal Plain area was found to be the Trek P 334 SE herbicide, with a value of 97.21%, followed by Gardoprim Plus with a calculated coefficient of 95.33% and the herbicide Wing P whose value was 94.15%. The lowest coefficient was recorded for the Casper herbicide, 73.28%.

The level of productions made this year in the herbicide experiment using the Alizee hybrid range between 3092 kg/ha at the Control variant and 8150 kg/ha when the Trek P 334 SE herbicide was applied. The increases recorded in all variants with herbicides, regardless of the active substance contained, have achieved very significant increases in production in comparison with the Control variant.

INTRODUCTION

In the context of increasingly obvious climate change, adapted technological measures are required in all cultures in order to prevent the increasingly pronounced influence that weeds, pathogens and pests have on the quantity and quality of production (Paraschivu Mirela et al., 2017).

Sorghum is one of the crops with high adaptability to slightly favorable ecological conditions (poor soils, arid climate), due to its high capacity to efficiently harness natural resources and increased tolerance to drought. Regarding the degree of weed growth in sorghum crops, in the US it is controlled with herbicides including *clethodim* (group 1), *fluazifop* (group 1), *imazetapyr* (group 2), *primisulfuron* (group 2), *dicamba* (group 4), *atrazine* (group 9) and *S-metolachlor* (group 15), alone or in mixtures (US-EPA, United States Environmental Protection Agency 2014, Wicks and Klein 1991, Werle, R. et al., 2017).

Weeds can be controlled either by applying pre-emergent or post-emergent herbicides. Integrated weed management uses a combination of biological, cultural, mechanical and chemical weed control measures to maximize economic profits. Strategies for integrated weed management are not sufficiently developed to control herbicide selectivity for *Sorghum bicolor (L.)*. The development of an integrated weed management plan, specific for sorghum, may become necessary if herbicide tolerant sorghum hybrids are sown, which limits the chemical control options or increases the germination and seedling rate.

MATERIAL AND METHOD

The experiment was carried out at ARDS Caracal during the 2019 year on an argic chernozem soil, medium rich in nutrient and with a humus content which varied between 3% to 4%. The soil in the arable layer (0-20 cm) has a lutearic texture with a clay content (particles below 0.002 mm) of 36.2%, an apparent density of 1.42 g/cm^3, a total porosity of 47% and one medium penetration rate (penetration resistance of 42 kg/cm^2).

The main aim of the research was to establish the most valuable variant of applied herbicides in order to ensure the cultural hygiene on grain sorghum. As experimented genotype we use grain sorghum hybrid ES Alizee from Euralis Company, a semi early hybrid, with high tolerance on drought, high tolerance to shatter and shake.

The plant's density used was 30 seeds/square meter and the fertilization background for the sorghum crop tested was $N_{150}P_{80}K_{80}$. The experience was placed in the field according to the randomized blocks method.

As variants we tested the herbicides with pre-emergent and post emergent applied time. The applied doses are presented in table 1. In all variants seeds were treated with the herbicide antidote Concep III (fluxofenin) to protect sorghum from the phytotoxic effect of antigraminaceous herbicides.

During the vegetation period of the sorghum were made biometric measurements in the field and in the laboratory the content of starch and protein was determined using the NIR Tango Brucker type analyzer. All data recorded, processed and interpreted were done using the method of analysis of variance (ANOVA, 2013).

Table 1

Variants of tested herbicide on grain sorghum in 2019 – ARDS Caracal

No.	Variants		Doses (l/ha)	Application time
1	Untreated - Control	-	-	-
2	Dual Gold	S-metolaclor 960 g/l	1.5	pre-emergence
3	Trek P 334 SE	Pendimetalin 64 g/l + Terbutilazin 270 g/l	3.5	pre-emergence
4	Wing P	Pendimetalin 250 g/l + Dimetenamid 212,5 g/l	3.5	pre-emergence
5	Gardoprim Plus Gold 500	S-metolaclor 312,5 g/l + Terbutilazin 187,5 g/l	3.5	pre-emergence
6	Casper	5% Prosulfuron+50% Dicamba	0.4	post emergence
7	Dicopur TOP 464 SL	Acid 2,4 D 344 g/l +Dicamba 120 g/l	1	post emergence
8	Buctril universal	Bromoxilin 280 g/l + Acid 2,4 D (ester) 280 g/l	1	post emergence

RESULTS AND DISCUSSIONS

Regarding the climatic conditions of the experiment made we can mention about the temperature, the data show in the figure 1, certifies that the agricultural year of *2019 was an excessively hot year*. Compared to the normal area, an average temperature of 12.7ºC was achieved, with 2.1ºC higher than the normal range for the area of 10.6ºC. Regarding the months of the warm period of the year (April - September) we find that in no month were temperatures lower than the multiannual average. The deviations were positive, ranging from 0.4ºC to 3.1ºC. It is noted as extremely hot in June, August and September, with a thermal surplus between 2.3ºC and 3.1ºC respectively.

During the vegetation period of the sorghum, from May to September, the total of 417.8 mm, numerically representing a sufficient value for a plant with relatively low requirements compared to the vegetation factor of water, but during the period of formation and filling of the grain, the months of August-September as very poor in precipitation, in August and September with a deficit of -49.7 mm and respectively -37.6 mm conduct to have resulted in the diminution of the elements of production, especially of the MMB.

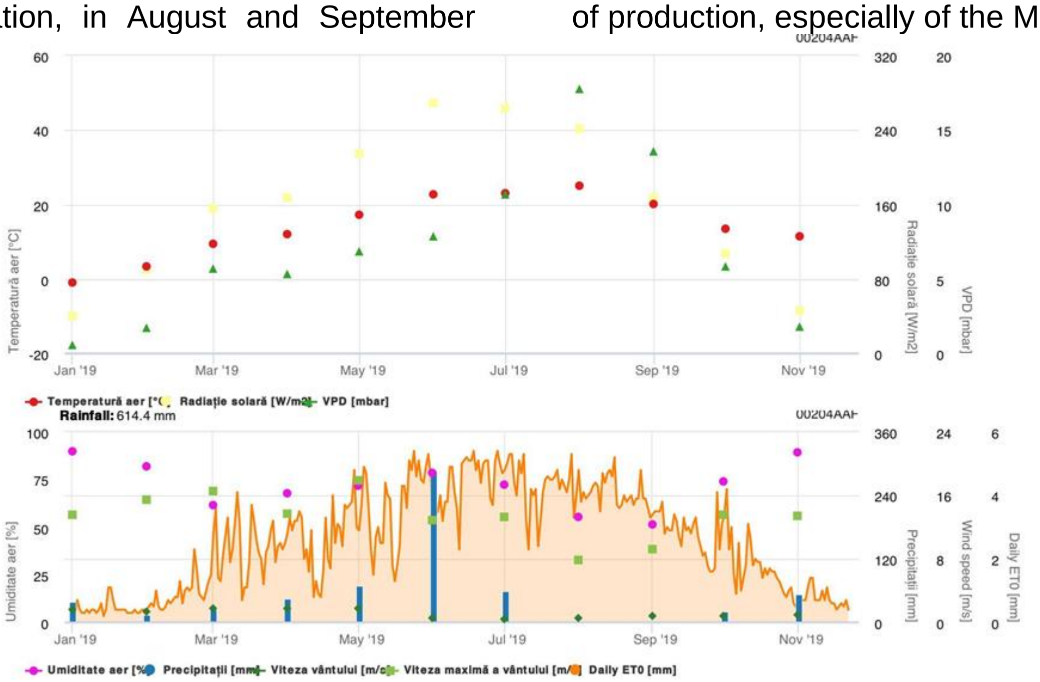

Figure 1 – Climatic conditions (temperature and precipitations) of ARDS Caracal in 2019

The efficacy of herbicides, assessed by EWRS (European Weed Research Society) notes on scale 1-9 (rating 1 - without damages, rating 9-crop is completely destroyed), performed dynamically, at 15, 30, 45 and 60 days after application (table 2) highlights the best results were obtained using the Trek P334 SE herbicide, applied in post-emergence at the dose of 3.5 l/ha, with an average of the EWRS marks, for the 15-60 days related the moment of application, being of the 2.4 note, followed by Gardoprim Plus Gold 500 herbicide, in a dose of 3.5 l/ha, applied also in pre-emergence of the seeds.

A high degree of weed control in the grain sorghum crop also registered the Wing P herbicide, with pre-emergence time of application, noted with a values of EWRS scale of 3.1.

From post emergence time of application group, the best values of EWRS note were registered at Dicopur Top herbicide, also of 3.1.

Table 2

Herbicides efficacy determined in dynamics on grain sorghum in 2019 – ARDS Caracal

No	*Variants*	*Doses (l/ha)*	*Time of application*	*Herbicide efficacy related application*				
				15 days	*30 days*	*45 days*	*60 days*	*Mean*
1	Untreated - Control	-	-	5	7,5	8,5	9	7.5
2	Dual Gold	1.5	pre-emergence	3	3.5	3	3.5	3.2
3	Trek P 334 SE	3.5	pre-emergence	2	2.3	2.3	3	2.4
4	Wing P	3.5	pre-emergence	2.2	2.3	3.5	4.3	3.1
5	Gardoprim Plus Gold 500	3.5	pre-emergence	2.2	2.2	3	3.3	2.7
6	Casper	0.4	post emergence	3.2	3.5	4.5	5	4.1
7	Dicopur TOP 464 SL	1	post emergence	2.5	2.5	3.3	3.8	3.1
8	Buctril universal	1	post emergence	3.2	3.2	4.5	4.5	3.8

Based on the field observation related the rate of weed destroyed by herbicides tested, we calculate the correct efficacy of herbicides (%) according with Abbott's formula (figure 2). As it can be easily observed the majority of the herbicides has a good rate of weed control. However, the most valuable variant proved to be Herbicide Trek P 334 SE applied in pre-emergences of seeds, with a value of 97.21% efficacy in weed control. On the second place was situated the variant with Gardoprim Plus Gold 500 SC, which reach a value of 95.33%, followed by Wing P with an efficacy of 94.15%.

Post emergence application of chemical molecules in the conditions of weed spectrum of ARDS Caracal led to a lower weed control capacity of 75.31% for Buctril universal and 73.28% in case of Casper herbicides.

The average/experiment has a good value of weed combating of 87.92%.

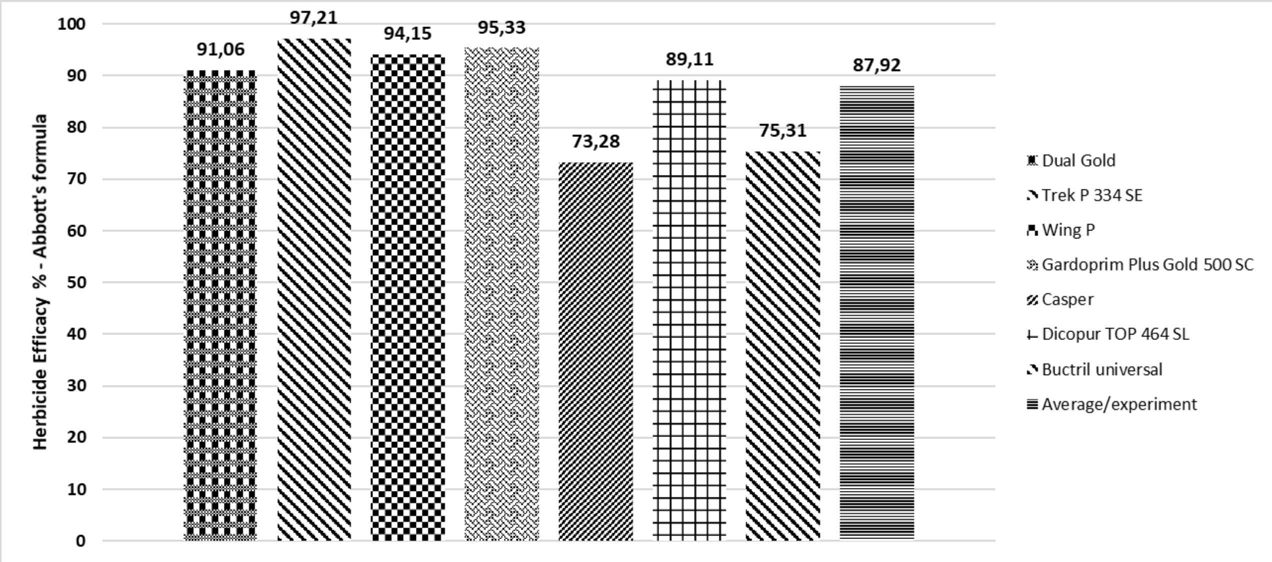

Figure 2 – Herbicides efficacy calculated using the Abbott's formula on grain sorghum at ARDS Caracal in 2019

The degree of weed in sorghum culture is negatively correlated with the elements of biometrics and productivity of the plant. Thus, in the untreated variant (Control 1), the lowest values were recorded at the plant's height, stalk diameter, leaf surface index, weight of 1000 grains (MMB) and hectolitric weight (MH).

Related to the plant's height – figure 3 – we registered the smallest values on this indicator at untreated variant (Control 1) of 103 cm, value explained by the high number of weeds from the variant who consumed water and nutrients. In comparison with the average/experiment, whose values were 115 cm, few of the variants gave plants with higher values than this: Trek P 334 SE with 127 cm, Gardoprim Plus Gold 500 SC with 121 cm, Dicopur Top 464 SL and Wing P with 119 cm.

The treatment applied in post emergence of Casper herbicide lead to register the smallest values of the plant's height from the variants with herbicides, of 107 cm, due the fact that until the treatment was made weeds had enough time to consume nutrients and water.

The results obtained at harvesting showed very significant increases in production on grain sorghum, between 3299 kg/ha to 5058 kg/ha, by applying chemical treatments for weed control, compared with the untreated variant (Control 1) of 3092 kg/ha (table 3).

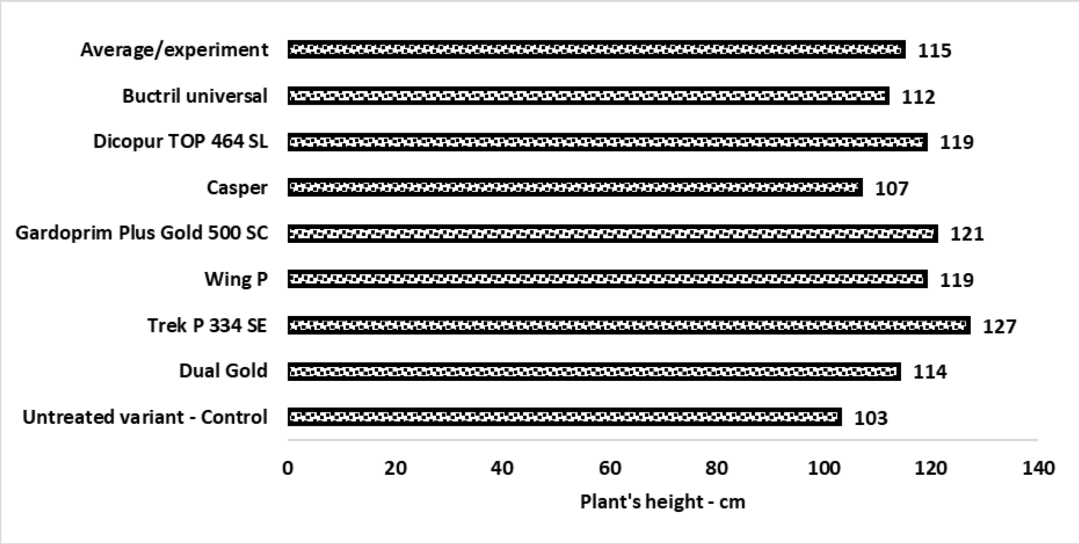

Figure 3 – Influence of herbicides on plant's height on grain sorghum at ARDS Caracal in 2019

Having a good capacity to efficiently capitalize of natural resources, grain sorghum can produce high yields under ecological conditions slightly unfavorable to other cereals (Antohe I. et al., 2002, Drăghici I., 1999). Numerous researches has shown that the technology elements could significantly influence the production potential of grain sorghum (Matei Gh., 2011, Narges Zand et al., 2013).

Table 3

The influence of the applied herbicides on yields registered on grain sorghum in 2019 – ARDS Caracal

Variants	Doses	Yield		Differences	Signification related C1	Differences		Signification related C2
	l/ha	kg/ha	%	kg/ha		%	Kg/ha	
Untreated variant – Control 1	*C1*	*3092*	*100*	*C1*	*C1*	45	-3769	OOO
Dual Gold	1.5	7426	240	4334	***	108	565	
Trek P 334 SE	3.5	8150	264	5058	***	119	1289	*
Wing P	3.5	7610	246	4518	***	111	749	
Gardoprim Plus Gold 500 SC	3.5	7967	258	4875	***	116	1106	*
Casper	0.4	6321	204	3229	***	92	-540	
Dicopur TOP 464 SL	1	7598	246	4506	***	111	737	
Buctril universal	1	6725	217	3633	***	98	-136	
Average/experiment – Control 2	*C2*	*6861*	*222*	*3769*	***	*100*	*C2*	*C2*
DL 5% - kg/ha		1327					965	
DL 1% - kg/ha		1785					1746	
DL 0,1% - kg/ha		2718					2254	

The most valuable variant for this year in grain sorghum crop made in ARDS Caracal it has proven to be one in which the herbicide Trek P 334 SE was applied, with a values of yield of 8150 kg/ha, with a very significant differences related to Control 1 (table 3). The product TREK P 334 SE contains the active substance pendimethalin, which acts on weeds, from the germination phase to the first stages of emergence and the active substance of terbuthylazine, which acts in post-emergence by inhibiting photosynthesis to control dicotyledonous weeds, the total effect being within 7 to 10 days, when the total destruction of the weeds can be observed.

Near this values were situated those productions registered on variants where we applied 3.5 l/ha of Gardoprim

Plus Gold 500 SC, with 7967 kg/ha, and Wing P herbicide with 7610 kg/ha.

In comparison with untreated variant, all the increases in productions obtained in this year were statistically considered as very significate and yields obtained in non-irrigated conditions very valuable.

Related to the second Control – average/experiment – whose values of yields was 6861 kg/ha, we've registered significant increases in production only on two variants: Trek P 334 SE with a positive difference of 1289 kg/ha and Gardoprim Plus Gold 500 SC with an increase of 1106 kg/ha.

At the opposite pole was situated the untreated variant with a negative differences of 3769 kg/ha. Negative differences have been recorded also at Casper and Buctril universal variants, but those differences from the statistically point of view considered as insignificant.

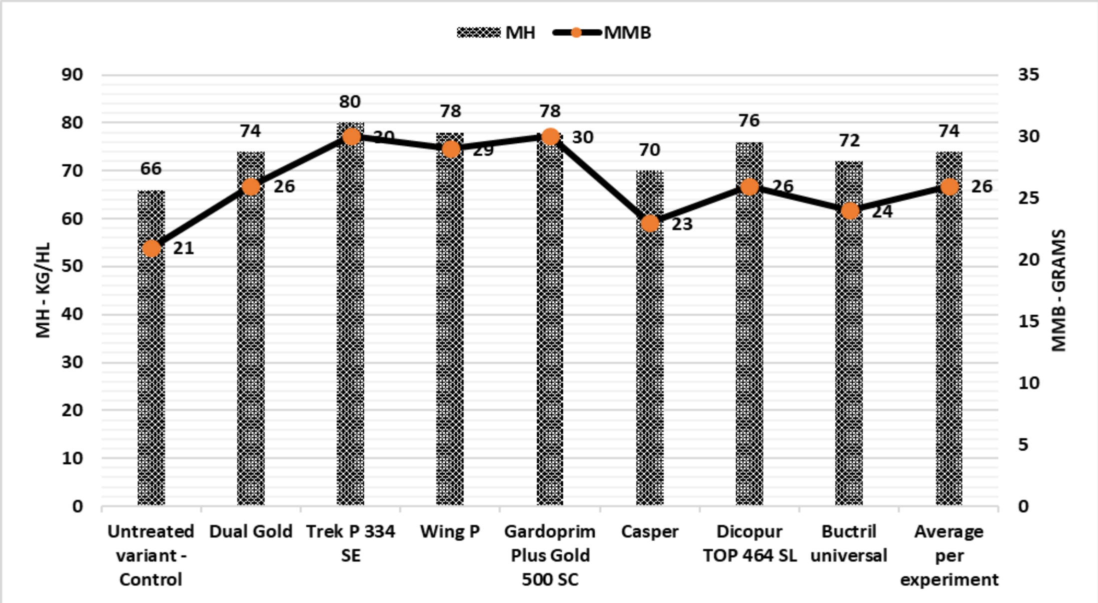

Figure 4 – Influence of herbicides on quantitative elements of production on grain sorghum at ARDS Caracal in 2019

The presence of weeds in agricultural crops makes its mark not only on the quantity but also on the quality of grain production. The same aspect we found in the experiment carried out using quantitative and qualitative indices of sorghum grains (figures 4 and 5).

Weeds reduce the yield and quality of grain sorghum by competing with sorghum for nutrients, water, and light (Grichar, W.J.et al., 2005). Also, weeds reduced grain sorghum harvest efficiency by increasing grain moisture and foreign material in harvested grains (Moore, J.W. et al., 2004).

If we taking in account values registered on *hectolitric weight (MH – kg/hl)* it can be observed that the range of this indicator belongs to interval of 66 kg/hl at untreated variant to 80 kg/hl at variant where was applied pre-emergent Trek P 334 SE herbicide. The majority of the tested variants had obtained values from 74 to 78 kg/hl. Lower values of hectolitric weigh had variant with Casper herbicide treatment, of 70 kg/hl, and variant with Buctril universal with a value of 72 kg/hl.

One of the components of yield is *MMB (mass of one thousand seeds)* which in our case had a similar value as in case of hectolitric weight, ranged from 21 grams at untreated variant to 30 grams to the variants where we applied Trek P 334 SE and Gardoprim Plus Gold 500 SC.

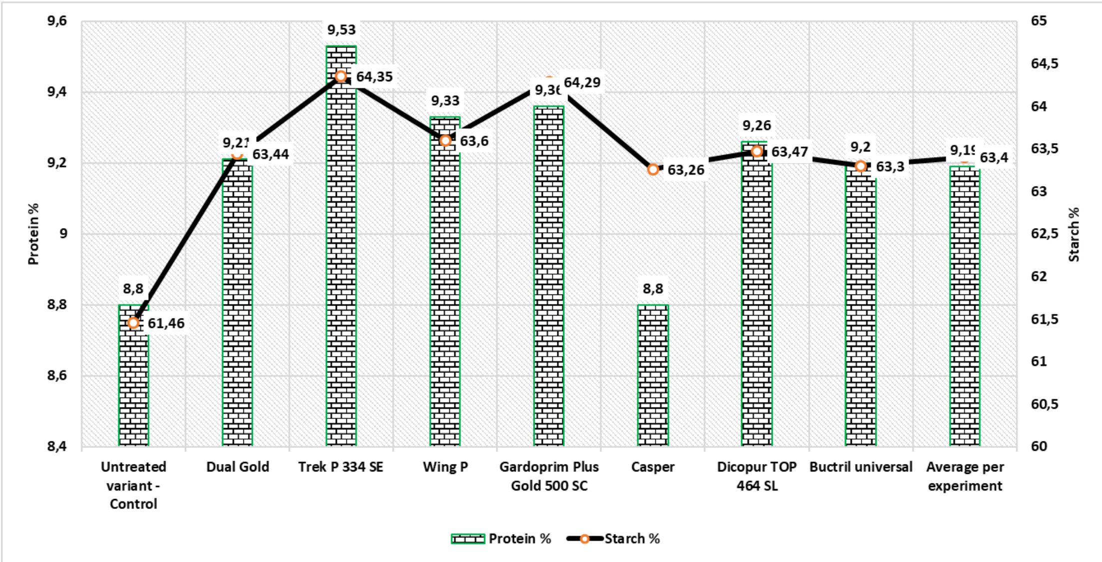

Figure 5 – Influence of herbicides on qualitative elements of production on grain sorghum at ARDS Caracal in 2019

Researchers and ethanol producers have shown that grain sorghum is a reasonable feedstock (technically acceptable, fits the infrastructure, and can be economically viable) for ethanol and could make a larger contribution to the nation's fuel ethanol requirements due his starch content (Renewable Fuels Association – RFA - 2007, Wu X. et al., 2006, 2007).

The recorded level of starch had been various due the treatment that the variant of grain sorghum has been made. High levels of the starch, over 63%, were observed at all variants where herbicides were applied, only the untreated variant obtained lower values, of 61.46%.

The protein content had a wide interval of range, from 8.8 % recorded at untreated variant and Casper herbicide to 9.53% when we tested Trek P 334 SE herbicide, which proved to be the best product with high influences thru the yield, from quantitative and qualitative point of view.

CONCLUSIONS

Variants with tested herbicides: Dual Gold (S-metolaclor 960 g/l) 1,5 l/ha, Trek P 334 SE (Pendimetalin 64 g/l + Terbutilazin 270 g/l) 3,5 l/ha, Wing P (Pendimetalin 250 g/l + dimetenamid 212,5 g/l) 3,5 l/ha, Gardoprim Plus Gold 500 SC (S-metolaclor 312,5 g/l + terbutilazin 187,5 g/l) 3,5 l/ha, Casper (5% prosulfuron+50% dicamba) 0,4 l/ha, Dicopur TOP 464 SL (Acid 2,4 D 344 g/l Dicamba 120 g/l) 1 l/ha and Buctril universal (Bromoxilin 280 g/l + acid 2,4 D (ester) 280 g/l) 1 l/ha proved to have a very good selectivity for grain sorghum plants;

The EWRS notations regarding the degree of weed presence in the untreated variant, highlights high values throughout the sorghum vegetation period, the grades being in the range of 5-9, with an average of 7.5;

The weed presence degree in grain sorghum culture is negatively correlated with the elements of biometrics and productivity of the plant;

The results obtained at harvesting showed very significant increases in production on grain sorghum, ranged between 3299 kg/ha to 5058 kg/ha, which conduct to highest productions of 8150 kg/ha on Trek P 334 SE variant,

The best control over the sprouting of the sorghum culture was achieved by the application of the product Trek P34

SE, at a dose of 3.5 l/ha, the increases being of 264% in comparison with the first Control – the untreated variant, and 119% related the second Control – the average/experiment.

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