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INFLUENCE OF SOME CROP MANAGEMENT SEQUENCES ON THE GRAIN YIELD AND QUALITY AT *SORGHUM BICOLOR* L. UNDER THE CENTER OF MOLDAVIA CONDITIONS

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ABSTRACT

In ARDS Secuieni soil and weather conditions, we performed a factorial experiment in which three sorghum cultivars grown in Romania were subjected to several crop management sequences. These crop management sequences included four sowing densities and four fertilization doses of nitrogen and phosphorus. The results obtained revealed that fertilization had positive influences on both the phenological characteristics of plants, and on the yield and quality. Sowing density had negative influences on phenological characters and on quality of the grain, but positive on yield. The correlations were positive between fertilization with nitrogen and phosphorus and number of shoots ha^{-1}, yield and grain quality and negative between sowing density and number of shoots ha^{-1} and grain quality.

Key words: sorghum, yield, chernozem, protein, fibre, sugar, density, fertilization.

INTRODUCTION

Sorghum (*Sorghum bicolor* L. Moench.) is a cereal with high importance, ranking fourth in the world according to its output and in fifth place as cultivated area (after wheat, rice, corn and barley). It has a large development and because of its use as food, especially in semi-arid areas of the world where climatic conditions offer limited conditions for agriculture. Such situations are mostly in Africa, Asia and Latin America, areas that are often prone to drought.
India has the largest area planted with sorghum, followed by Niger and Sudan and is ranked second in annual production, after the USA (FAO, 1995; ICRISAT, 2004; Nadia et al., 2009).

The species can be an excellent source of starch, protein, sugar, fibre, being cheaper than corn, because the costs per ha are lower than corn (Shinde, 2005; Singh et al., 2007; 2009; Claver et al., 2010).

The climatic evolution towards heat and aridity in the Balkans, where Romania is also situated, compels to a reconsideration of sorghum as: cereal food, fodder plant, technical plant, for the chemical industry (stationery and textile cellulose, plastics) construction materials industry and craft industry (household and industrial brushes, brooms, braids) (Volf, 2009).

Improvement of some crop management sequences of sorghum is a matter of great importance for our country, in order to obtain high yields to ensure the necessary food, feed, raw material in the production of bioethanol - considered a fuel of the future. Thus the objective of the research conducted at the Agricultural Research - Development Station Secuieni was to study the influence of some crop management factors (density: 15 germinating grains m^{-2}, 20 g.g. m^{-2}, 25 g.g. m^{-2}, and 30 g.g. m^{-2} and fertilization: N_0P_0, $N_{40}P_{40}$, $N_{80}P_{80}$, $N_{120}P_{120}$) on the yield and grain quality at three sorghum hybrids (Fundulea 32, Alize, Armida).

MATERIAL AND METHODS

A factorial experiment was organized in 2013-2015 in the experimental field of Agricultural Research - Development Station Secuieni, Neamt County, using a split-plot design in three replications.

The trial was conducted on a typical cambic chernozem soil type, middle texture, acid: pH_{H2O} – 5.98, characterized as: well-

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supplied in phosphorus (77.6 ppm PAL), Ca (13.6 mEq/100 g soil Ca) and Mg (1.8 mEq/100 g soil Mg), middle supplied in active humus (1.88%) and nitrogen (16.2 ppm $N\text{-}NO_3$) and poorly supplied in potassium (124.6 ppm K_2O).

The crop management parameters targeted in this paper are the sowing density and fertilization. It is well known that the sowing density is important due to its positive correlation with the number of present plants that forms the plant density in field and at harvest and, the mineral fertilizers are of special importance in increasing the yield of sorghum for grain.

The experimental factors studied in this experiment were of A x B x C type, where: A factor was represented by the hybrid (a_1 − Fundulea 32, a_2 − Alize, a_3 − Armida), B factor, by the provided seeding densities (b_1 − 15 germinating grains m^{-2}, b_2 − 20 germinating grains m^{-2}, b_3 − 25 germinating grains m^{-2} and b_4 − 30 germinating grains m^{-2}), and the C factor was represented by the nitrogen and phosphorus fertilization (c_1 − unfertilized, c_2 − $N_{40}P_{40}$, c_3 − $N_{80}P_{80}$ and c_4 − $N_{120}P_{120}$).

The chemical composition of grains was determined in laboratory after SR EN ISO 20483:2007 and STAS 110-3: 1995, and biometric and specific measurements were performed in field, during the sorghum growing season. Sampling was done when the grains reached a humidity of 18%.

RESULTS

The tested crop management sequences influenced both the phenological characteristics of plants and the yield and quality of grains.

The fertilization with nitrogen and phosphorus contributed to increasing the number of tillers/plant, but the sowing density negatively influenced their formation (Figures 1 and 2).

Between the fertilization with nitrogen and phosphorus and the number of shoots/ha, a direct and close correlation was established, the correlation coefficient (r) was statistically very significant (Figure 1).

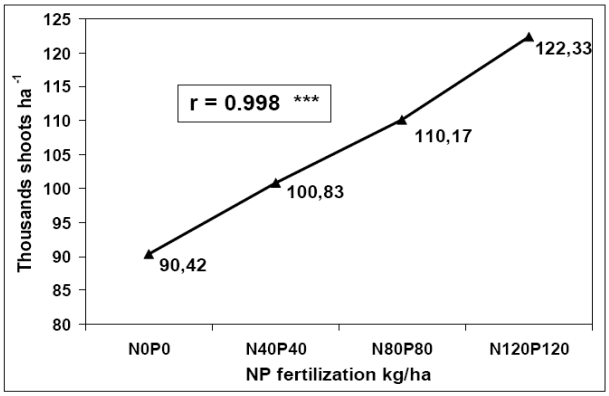

Figure 1. The relation between the nitrogen and phosphorus fertilization and the number of shoots ha^{-1} in *Sorghum bicolor* L. (2013-2015 average)

The correlation between the sowing density and number of shoots, however, was negative, and the negative correlation coefficient (r) was very significant (Figure 2).

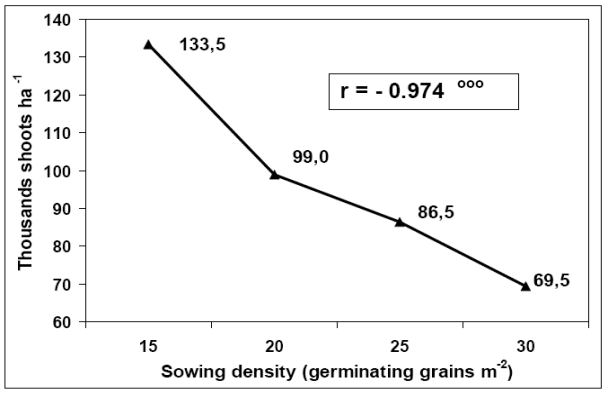

Figure 2. The relation between the sowing density and the number of shoots ha^{-1} in *Sorghum bicolor* L. (2013-2015 average)

The average yields achieved in the analysed period were directly influenced by the tested crop management factors. They varied very widely, from 2122 kg ha^{-1} (Alize x 15 g.g. m^{-2} x N_0P_0) up to 9798 kg ha^{-1} (Armida x 30 g.g. m^{-2} x N120P120) (Table 1).

The largest yield increase per 1 kg fertilizer active ingredient (92.80 kg grain/1 kg fertilizer a.i.) was obtained from the interaction between $N_{40}P_{40}$ x Armida x 30 g.g. m^{-2} (Table 1).

Compared to the trial average, the statistically significant yield increases started from the N40P40 fertilization dose. These increases were achieved in the variants sown with the density of 30 g.g. m^{-2} and they were very significant (1426 kg ha^{-1}, 1054 kg ha^{-1}) in Armida and Fundulea 32 hybrids and distinctly significant (562 kg ha^{-1}) in the Alize hybrid (Table 1).

Table 1. The influence of the interaction hybrids x fertilization x sowing density on sorghum grain yield during 2013-2015

Fertilization	Hybrid	Density (g.g. m^{-2})	Yield (kg ha^{-1})	% to trial average	Diff. (kg ha^{-1})	Significance	Kg grains/ 1 kg fertilizer a.i.
N_0P_0	Fundulea 32	15	2384	40	-3615	ooo	-
		20	3679	61	-2319	ooo	-
		25	4647	77	-1351	ooo	-
		30	5722	95	-277		-
	Alize	15	2122	35	-3877	ooo	-
		20	3447	57	-2551	ooo	-
		25	4262	71	-1737	ooo	-
		30	5377	90	-621	oo	-
	Armida	15	2401	40	-3598	ooo	-
		20	3655	61	-2343	ooo	-
		25	4386	73	-1612	ooo	-
		30	5547	92	-451	o	-
$N_{40}P_{40}$	Fundulea 32	15	3991	67	-2008	ooo	49.88
		20	5031	84	-968	ooo	62.88
		25	5918	99	-80		73.98
		30	7052	118	1054	***	88.14
	Alize	15	3586	60	-2412	ooo	44.83
		20	4857	81	-1142	ooo	60.71
		25	5832	97	-167		72.89
		30	6560	109	562	**	82.00
	Armida	15	3557	59	-2441	ooo	44.46
		20	5011	84	-988	ooo	62.63
		25	6016	100	18		75.19
		30	7424	124	1426	***	92.80
$N_{80}P_{80}$	Fundulea 32	15	4891	82	-1108	ooo	30.57
		20	6070	101	72		37.93
		25	7130	119	1132	***	44.56
		30	8382	140	2384	***	52.39
	Alize	15	4523	75	-1476	ooo	28.27
		20	6093	102	95		38.08
		25	7206	120	1208	***	45.03
		30	8124	135	2126	***	50.78
	Armida	15	4957	83	-1042	ooo	30.98
		20	6063	101	65		37.89
		25	7413	124	1415	***	46.33
		30	9201	153	3203	***	57.50
$N_{120}P_{120}$	Fundulea 32	15	6284	105	286		26.18
		20	7400	123	1402	***	30.83
		25	8414	140	2416	***	35.06
		30	9373	156	3375	***	39.05
	Alize	15	5716	95	-282		23.82
		20	7517	125	1519	***	31.32
		25	8628	144	2630	***	35.95
		30	9101	152	3103	***	37.92
	Armida	15	6384	106	386	*	26.60
		20	7520	125	1522	***	31.33
		25	9248	154	3250	***	38.53
		30	9798	163	3800	***	40.82
Trial average			5998	100	Mt.	-	-
LSD A x B x C (kg ha^{-1})			5% = 1% = 0.1 % =		385 486 649		

When the dose of nitrogen and phosphorus of 80 kg a.i. ha^{-1} was applied very significant yield increases were obtained in all the variants sown with 25 g.g. m^{-2} and 30 g.g. m^{-2}. By increasing the dose with another 40 kg a.i. ha^{-1} nitrogen and phosphorus, very significant yield increases were observed in all the variants sown with densities greater than 15 g.g. m^{-2} (Table 1).

In all the unfertilised variants sown with densities smaller than 30 g.g. m^{-2} were achieved very significant negative yield differences were obtained (Table 1).

Both between the NP doses and the grain yields, and between densities and yields, there was a positive close correlation, the correlation coefficients being very significant (Figures 3 and 4).

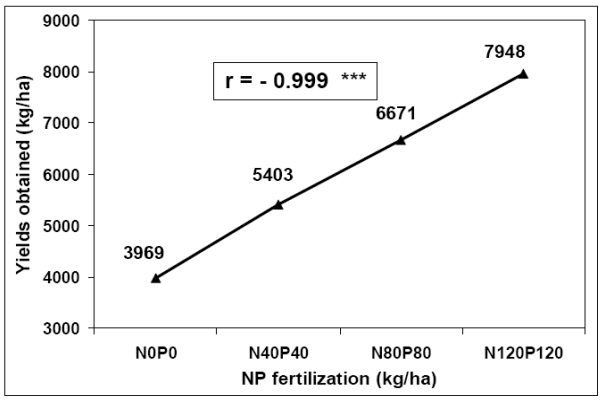

Figure 3. The relation between the nitrogen and phosphorus fertilization and the yield in *Sorghum bicolor* L. (2013-2015 average)

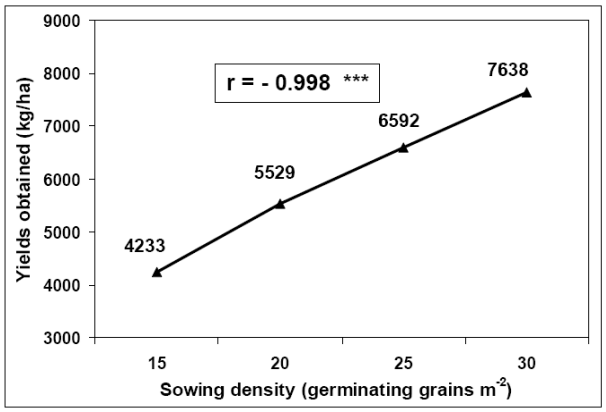

Figure 4. The relation between the sowing density and the yield of *Sorghum bicolor* L. (2013-2015 average)

The studied factors (hybrids, density, fertilization) also contributed to changes of grains chemical content.

Thus, following the results it was observed that between the fertilization doses with nitrogen and phosphorus and the content in protein (%) has been established a direct and very close correlation. The correlation coefficients (r) were statistically ensured and interpreted as very significant. The sugar and fibre content was negatively influenced and in the case of sugar content the correlation coefficients (r) were statistically ensured and interpreted as negative significant (Figure 5).

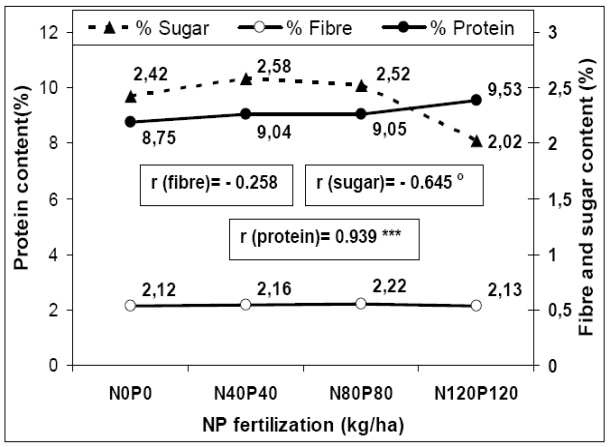

Figure 5. The correlation between the fertilization and the chemical content of *Sorghum bicolor* L. grains

Increasing the sowing density had a negative impact on grain quality, the correlation between these two variables was indirect, the correlation coefficients were statistically ensured and interpreted as negative very significant (protein) and negative distinctly significant (sugar) (Figure 6).

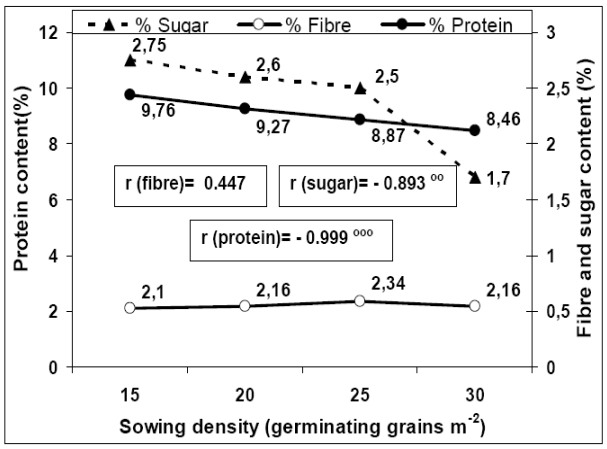

Figure 6. The correlation between the sowing densities and the chemical content of *Sorghum bicolor* L. grains

CONCLUSIONS

Sorghum cultivation in Romania can have strong social influences, favorable both through the creation of new jobs and the use of the whole agricultural area of the country.

The maximum level of the yields was recorded in the variants fertilized with $N_{120}P_{120}$, and the minimum level in the unfertilised variants.

Increasing sowing density influenced positively the grain yield, its maximum level was recorded in the variants sown with 300000 germinating grains ha^{-1}, and the minimum in the variants sown with 150000 g.g. ha^{-1}.

The highest yield increases/1 kg a.i. fertilizer with nitrogen and phosphorus were recorded in the variant Armida x $N_{40}P_{40}$ x 300000 g.g. ha^{-1}.

The highest grain yields were recorded in the variants sown with Armida hybrid, at a density of 300000 g.g. ha^{-1} and fertilized with $N_{120}P_{120}$, which leads us to recommend the introduction of this alternative cultivation technology specific for the Center of Moldova for sorghum.

Grain quality was influenced by the studied crop management factors;

With the increase of the seeding density grain yield significantly increased, but the grain quality decreased, and by increasing the doses of fertilization with nitrogen and phosphorus, both production and quality of grains significantly improved.

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