UDC 633.62
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PECULIARITIES OF SUGAR SORGHUM GROWING AS A RAW MATERIAL FOR BIOFUEL PRODUCTION IN CONDITIONS OF SOUTH-WESTERN FOREST STEPPE OF UKRAINE

In the article, the research results on growing sugar sorghum in conditions of South-Western Forest Steppe of Ukraine are highlighted. A correlation between sugar sorghum yield productivity and quality, and stands density of such crop and their protection measures from weeds on two soil types is established.

Keywords*: sugar sorghum, plants density, crop capacity, herbicide, green mass.*

Introduction. Recently, due to deterioration of environmental condition, a search of new ecologically clean energy sources from renewable raw material for usage as a fuel has been obtaining more and more urgency. At present, a lot of states of South and North America, as well as those of Europe and Asia, are solving energetic problems on account of using biofuel of plant origin [1].

In Ukraine, sugar sorghum may become one of potential raw material sources for sugar-containing matters supply, which is a precious source of raw material for bioethanol production. The cell sap of sugar sorghum contains up to 20 % sugar in leaves and stems.

The scientists' research results of a range of states point to the fact that at present in nature, there is no other plant existing which could synthesize sucrose so fast, which among cell sap carbohydrates makes 60-80 % [2-4].

In a world farming, sorghum occupies over 30 mln ha. In Russia, sorghum is grown on area about 100 thousand ha. In our country, at the beginning of 90-s, the sowing areas of this crop were 20-25 thousand ha. Beginning from 2000, sorghum areas increased from 5000 to 76000ha. The soil-climatic conditions of Ukraine are quite favourable for all sorghum species production, including the sugar one, the vegetative biomass of which is an important raw material for biofuel production [5].

Recently, such crop production has become a rather actual theme, for an interest in sugar sorghum processing as an alternative source for biofuel production (biobuthanol, biogas, fuel pellets, biosyngas, biopetroleum, etc.) as in an advanced raw material for obtaining sugar-containing products (sugar, food syrup, honey, etc.) has increased [6].

That is why, the aim of my research has become the investigation of sugar sorghum growth and development peculiarities on alkaline black soil and on grey forest soil in conditions of South-Western forest Steppe of Ukraine.

Materials and methods. The research was conducted on trial field of Bukovinian state agricultural research station in conditions of South-Western Forest Steppe of Ukraine, in 2011-2013. The effect on sugar sorghum productivity of stands density and protection means of crops from weeds on alkaline black soil and on grey forest soil was investigated. Four stands densities were used – 90, 120, 150, and 180 thousand/ha; the following crops protection means from weeds were implemented: – without implementation of crops protection means from weeds; conducting two hand-weeding at plants vegetation beginning, and applying a herbicide Prime-Extra Gold, 50% s.c. (s - metholachlorine – 400g/L + atrasin 320g/L) – 3,0L/ha.

A total site area is 25 m^2, accounting one – 20 $м^2$, repetition – 3-times. For the research, the seed of sugar sorghum hybrid «Medoviy ("Honey")» of home selection was used. The accountings and surveys were carried out according to generally accepted methods for cereals [7].

Results and discussion. Accessing the weather-climatic conditions formed in years of research conducting, one may note the following: deviations of such basic meteorological elements as air temperatures and precipitation quantities, from average multi-annual values, did not approach

critical indicators, which as a whole has favoured the harmonious shoots obtainment, and in further has allowed to form high yield of sugar sorghum green mass (Table 1).

Table 1

Meteorological conditions for years of research conducting, the data of BSARS meteopost

Months	Indicators							
	Precipitation quantity, mm				Average daily air temperature, ^{0}C			
	2011	2012	2013	2011-2013	2011	2012	2013	2011-2013
I	19,1	19,7	35,6	32	-2,4	-3,1	-4,5	-4,8
II	28,3	35,4	31,5	33	-2,6	-10,3	-0,8	-3,4
III	32,8	18,0	67,0	39	1,9	4,7	-0,2	1,8
IV	39,3	90,3	62,1	57	10,2	13,0	11,1	8,3
V	28,2	68,7	101,5	73	16,2	16,8	17,7	14,5
VI	166,0	63,7	137,2	89	20,8	21,1	20,2	17,4
VII	78,5	38,1	22,4	94	21,9	23,7	19,6	19,2
VIII	34,0	60,5	48,3	74	20,8	21,6	20,5	18,6
IX	21,8	25,9	83,5	57	17,7	17,1	14,1	14,2
X	15,3	32,0	5,0	48	10,8	11,3	10,6	8,8
XI	30,0	28,9	33,0	38	1,9	2,1	2,4	2,3
XII	25,6	31,2	35,0	33	-2,3	-2,6	-1,3	-2,4
Precipitation sum 12 months	518,9	512,4	662,1	667				
Average year t					9,5	9,6	9,1	7,8

However, weather conditions in years of research conducting were forming differently. Thus, 2011 in a whole was droughty, excluding the second half of June, when showers passed. During the crop sowing period and shoots obtainment, there was significantly less precipitation than that of norm; humidity deficiency made - 44,8mm. Exactly the humidity deficiency in soil in that period, in my opinion, stipulated the low effectiveness of herbicide Prime-Extra Gold action. That is why, the crop green mass yield on variants with herbicide application by its value acceded the yield of variants with hand-weeding in 2011. This difference made 10,9-14,3t/ha at using plant stands different densities on alkaline black soil, and 10,7-22,0t/ha – on grey forest soil. The meteorological conditions in 2012 – 2013 were more favorable for harmonious shoots obtainment and crop growth and development; in May, there was quite enough precipitation. A significant soil humidity favoured the high effectiveness of soil herbicide action. This is explaining the fact that the yield of green- and dry mass in 2012 – 2013 was the highest on trial variants with herbicide application on both soil types, and at using different densities (see Fig. 1, 2).

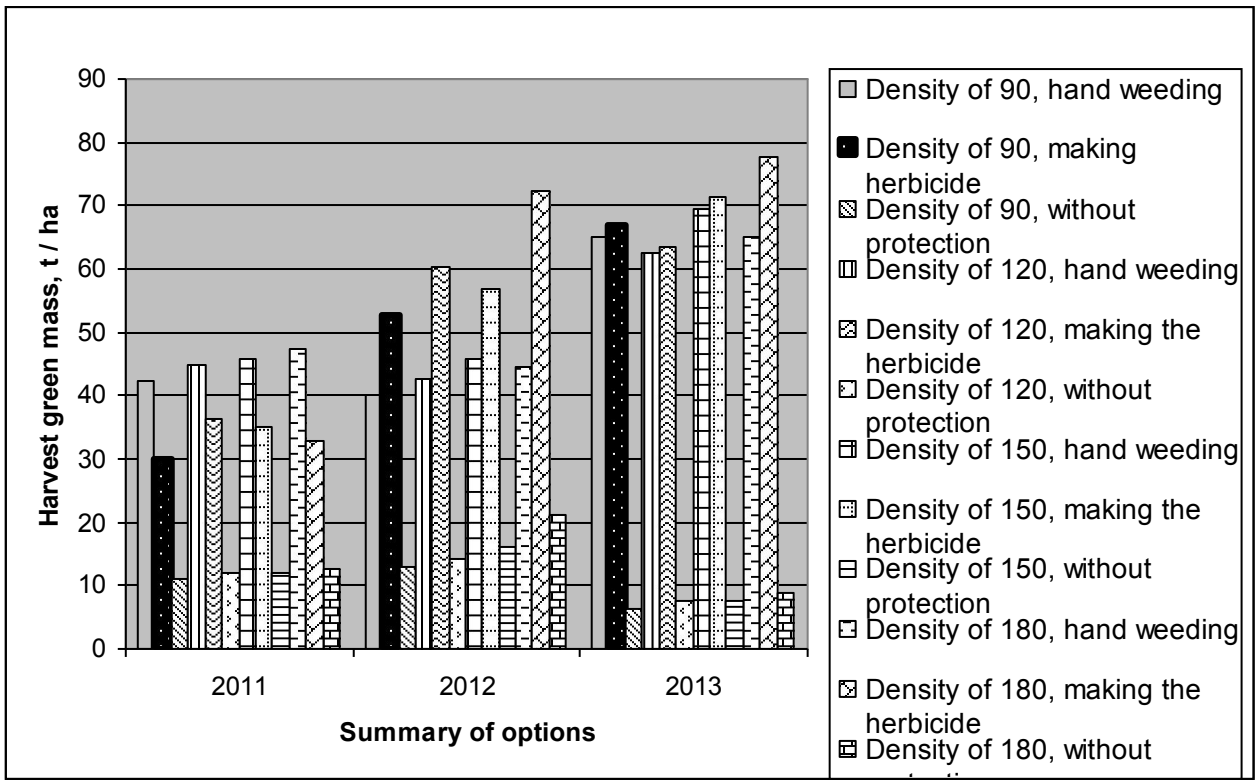

Fig. 1. Green mass crop capacity of sugar sorghum hybrid Medoviy ("Honey")» on alkaline black soil, in 2011-2013

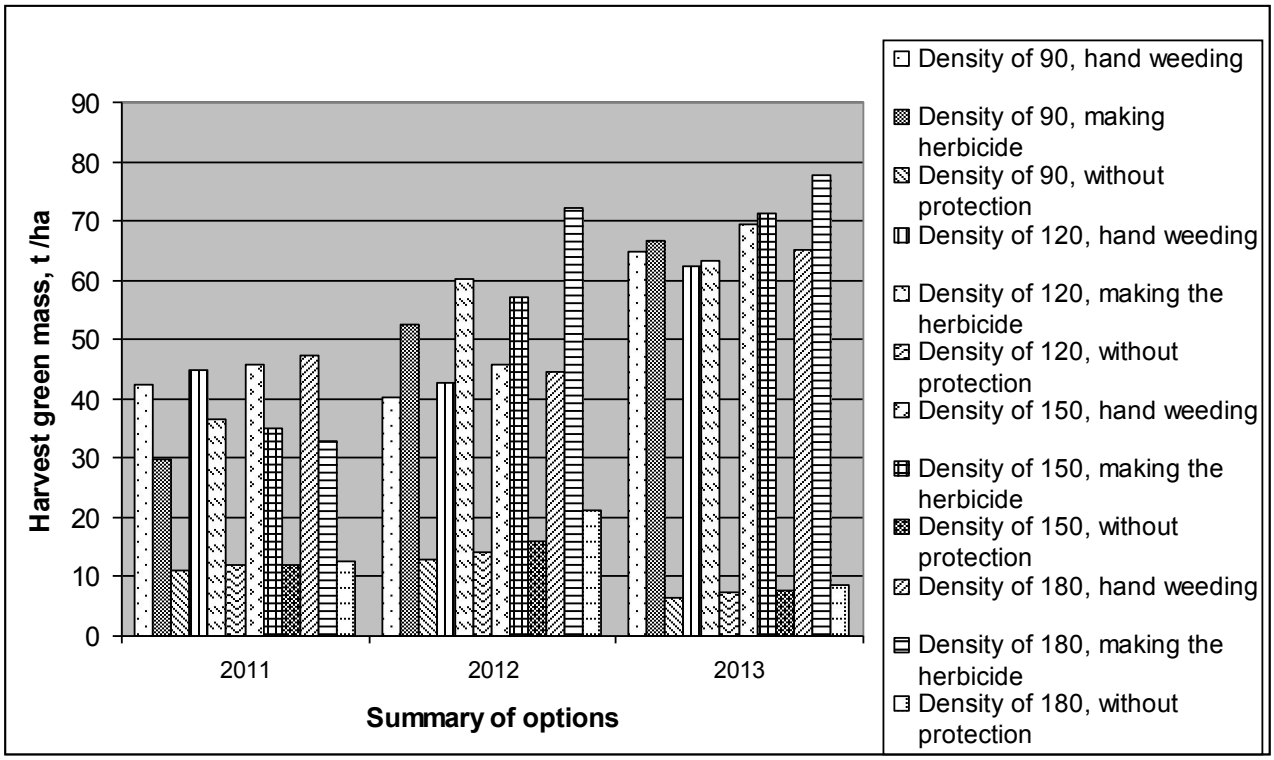

Fig. 2. Green mass crop capacity of sugar sorghum hybrid «Medoviy ("Honey") » on grey forest soil in 2011-2013

For three years of research, on average, the highest yield on alkaline black soil has been formed on the variant with density 180 thousand/ha at herbicide usage, exactly – 61 t/ha of green mass and 18,33 t/ha of dry mass. On grey forest soil, the maximum yield has been obtained on analogic variant, and has made 47,3 t/ha of green mass, and 12,2 t/ha of dry mass. In terms of one

density, the yield indicators of green- and dry mass, on average, for the three years of research, have been more in value on variants with herbicide application than the analogic indicators on variants with hand-weeding. The least yield indicators of green- and dry mass are obtained on variants without conducting crop protection measures from weeds. Thus, the average crop capacity indicators for the three years, of green mass on alkaline black soil have been 3,7-4,7 – fold less than those of hand-weeding, and 4,3-4,9 -fold – than those of herbicide application variant. On grey forest soil, on weeded trial sites, a green mass yield decrease has made 4,6-5,7 -fold.

On sites without conducting crop protection measures from weeds, heir quantity in different research years has been within the limit from 1,44 mln. pc/ha (in weight measurement – 3,68 t/ha) at using sugar sorghum density 180 thousand pc/ha, to 3,35 mln. pc/ha (in weight measurement 6,16 t/ha), at density 90 thousand pc/ha.

Among the present weed plants on sites variants without protection measures, green foxtail is dominating. On alkaline black soil, its part makes on different trial variants from 54,55 to 77,58 %. On grey forest soil, this indicator makes from 72,41 to 94,44 %. On alkaline black soil, as well as on grey forest soil, with increase of stand density of sugar sorghum, the general mass of weeds is decreasing.

The results of phenological surveys of sugar sorghum plants on two soil types have shown that already after fourth leaf formation on sorghum plants, their significant lag in development is noted on variants without herbicides application, intercrop tillage, and hand-weeding. The plants height indicators in period of crop harvesting on sites with herbicide application have exceeded the analogic indicators of variants without protection measures, averagely on 125,6cm on alkaline black soil, and on 106,2cm on grey forest soil.

The plants stands density influences the plants productivity by following means: as the density is increasing, the green mass yield is increasing also. Such a tendency is observed in all the years of research on both soil types. Thus, averagely for three years, on alkaline black soil, the difference between indicators of green mass crop capacity at density 90 thousand/ha and at 180 thousand/ha on variants with hand-weeding has made 3,7t/ha, and on variants with herbicide application – 11,23t/ha. On grey forest soil, such indicators have made 9,4t/ha and 6,6t/ha, respectively.

Crop capacity indicators of green- and dry mass on alkaline black soil were higher than those on grey forest soil analogic variants, in all research years. Averagely, this difference has made 25,5-50,7 % on variants with hand-weeding, and 28,9-40,0 % on variants with soil herbicide application.

Conclusions. It is established, that mostly among the factors investigated, that is, plants stands density, crops protection measures from weeds, and soil type, -exactly the protection measures have influenced the plants growth, development, and productivity in sum. It is impossible to obtain a crop green mass high yield without proper crops protection from weeds, on first stages of plants development (up to the latters reaching 1m in height). It is possible to eliminate weeds at growing sugar sorghum with the help of a soil herbicide Prime-Extra Gold. However, it is necessary to apply it into a humid soil; that is why in a droughty spring period, one should pay a special attention to timely humidity closing, and its maintenance and accumulation in soil with the help of agrotechnical measures, by rains falling-out degree in pre-sowing period. The next factor is plants stands density. With density increase, the green- and dry mass yield increase also. Concerning soil factor, on alkaline black soil the green mass yield indicators in different years of the research have been more than those of analogical variants on grey forest soil, by 23,7-99,1 %.

On alkaline black soil, at plants stands density 180 thousand/ha and using soil herbicide Prime-Extra Gold 3 L/ha, at favourable weather-climatic conditions, it is possible to obtain a yield of crop green mass up to 77,8 t/ha; of dry mass – up to 20,4 t/ha. On grey forest soil, at usage of the analogic density and soil herbicide, one may obtain up to 50 t/ha of green mass, and 14,1 t/ha of dry matter. At using the green mass as a raw material for rare fuel kinds production, bioethanol escape makes 4746 L/ha on alkaline black soil, and 3193 L/ha on grey forest soil. In conditions of bio-raw material usage for biogas production, its output will make 10997 and 6622 m^3/ha, respectively.

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Анотація

Гунчак Т.І.

Особливості вирощування сорго цукрового в якості сировини для виробництва біопалива в умовах Південно-західного Лісостепу України

У статті висвітлено результати одосліджень по вирощуванню сорго цукрового в умовах Південно-західного Лісостепу України. Встановлено взаємозв'язок між продуктивністю та якістю урожаю сорго цукрового та густотою насаджень цієї культури й заходами захисту посівів від бур'янів на двох типах ґрунту.

***Ключові слова**: сорго цукрове, густота рослин, урожайність, гербіцид, зелена маса*

Аннотация

Гунчак Т.И.

Особенности выращивания сорго сахарного в качестве сырья для производства биотоплива в условиях Юго-западной Лесостепи Украины

В статье отражены результаты исследований по выращиванию сорго сахарного в условиях Юго-западной Лесостепи Украины. Установлена взаимосвязь между производительностью и качеством урожая сорго сахарного и густотой насаждений этой культуры и мерами защиты посевов от сорняков на двух типах почвы.

***Ключевые слова:** сорго сахарное, густота растений, урожайность, гербицид, зеленая масса*