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RESERVES FOR INCREASING THE YIELD OF SUNFLOWER SEEDS IN THE UKRAINIAN STEPPE

SUMMARY

The highest yields of sunflower hybrids are provided when plants are placed after surface plowing and chiseling at a depth of 25-27 cm. Reducing the depth of cultivation to 10-12 cm and direct sowing in untreated soils leads to a significant decline in sunflower yield by 20-30%. An important factor in increasing the crop yield is the use of fertilizers (N₄₀P₆₀K₃₀), which is better during the basic soil treatment in the autumn or under pre-sowing cultivation, which provides an increase in the yield of seeds at a level of 0,2-0,4 t / ha. High efficiency in the technology of sunflower growing is also provided by the use of physiologically active substances. The yield increasing from their application varies within 0,09-0,32 t / ha or 3,2-10,4%.

Keywords: sunflower, seeds, mineral fertilizers, soil cultivation, herbicides, yield.

INTRODUCTION

The level of weed infestation directly affects the intensity of competitive relationship between sunflower crops and weeds. Weed suppression in the sunflower crop has to be done with adequate herbicides and in due time in order to suppress a significant reduction in morphological and yield parameters (Simić et al, 2011). For the control of dicotyledonous weeds in sunflower, active ingredients such as linuron, flurochloridone, oxyfluorfen, pendimethalin, prosulfocarb, bifenoxy, acifluorfen, flumioxazin, and lenacil are often used (Kilinc et al. 2011) in combination with acetamide herbicides (acetochlor, dimethenamid, pethoxamid, metolachlor, flufenacet, and propisochlor), which are intended for the control of grass weeds. Soil herbicides can influence directly the emergence and physiological process of cultivated plants and weeds. These chemicals can also change processes of nutrient transformation and indirectly effect on mineral nutrition of plants. Such herbicides as Afalon Dispersion (linuron), Galigan 240 EC (oxyfluorfen), Pledge 50 WP (flumioxazin), Proponit 720 EC (propisochlor) and Stomp 330 (pendimethalin) with the highest field suggested doses decreased

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fresh- and dry weight of four weeks age sunflower shoots in different extent, moreover influenced mineral nutrition of two hybrids unequally (Nadasy *et al.*, 2008).

The efficacy of linuron, prosulfocarb, and pethoxamid was strongly affected by soil moisture and was insufficient under dry conditions. The majority of herbicides showed good selectivity for sunflower. Crop injury rate of 5–15% was recorded after application of flurochloridone and acetochlor. For flurochloridone, the phytotoxicity increased due to irrigation after herbicide application. The highest sunflower injury rate (27–35%) was recorded after application of oxyfluorfen. Field experiments were conducted at Agricultural Research and Development Institute from Fundulea (Romania) on a leached chernozem soil, well drained, formed on loess, with 33% clay content and 2.8% organic matter in the arable layer (Petcu Gh. and Petcu E., 2006). The developed modern crop production technologies should be improved in response to concerns about environmental impacts of agriculture towards cropping intensification reduction. In this context, choice of a good soil tillage method management is an important decision to improve grain yield and quality.

The relation between crop growing and soil tillage treatment are play important role in agricultural production (Gürsoy *et al.*, 2014). Soils under conventional tillage (CT) generally have lower bulk density and associated higher total porosity within the plough layer than under no tillage (NT). No-till farming can reduce soil erosion, conserve soil moisture and minimize labor and fuel consumption. no differences were found between the NT and CT. There were also no significance differences in content of protein, oil and ash among six tillage methods. The highest fuel consumption was measured in conventional method (CT) whereas the lowest value was found in direct seeding method as 33.48 L ha⁻¹ and 6.6 L ha⁻¹, respectively (Halvorson *et al.*, 1999). Soil compaction represents an important issue in the actual context of agricultural system sustainability (Aboudrare *et al.*, 2006). Research on the various developments of root systems under tillage has been explored for many crops, whether for the biomass area or the underground, but very little concerns Sunflower (*Helianthus annuus* L.). Under compacted soil, major changes in the sunflower's root architecture occurred (55% of root length, 67% of root surface, and 42% of root diameter) and root system exploration was negatively impacted (assessed through the use of semivariogram). This resulted in a decrease of deep root exploration and in an increased lateral growth. Modifications of leaf surface, biomass, yield, and kernel components were also reported. Those modifications were the consequences of soil compaction (Mirleau-Thebaud *et al.*, 2017; Fuentes *et al.*, 2009). At the start of No-till sunflower planting in Argentina, weed control become a more complex topic. Herbicides for preplant chemical fallow provided effective weed control. Difficulties rose with weeds emerging after planting because two widely used pre-emergence residual herbicides (acetochlor and flurochloridona) were less effective, being dependent of rainfall and retained by stubble. As a result of research on control programs including other sunflower selective residual herbicides (sulfentrazone, diflufenican, prometryn), combined tank mixes with glyphosate, preplant plus preemergence split applications, etc. (Montoya, 2008) weed control was improved.

Crop preemergence herbicides will always be at some risk of incomplete control because rainfall must move herbicides into the soil prior to weed seed germination. While rescue treatments of escaped grasses are effective, most broadleaf weeds cannot be controlled with postemergence herbicides because the two available (aclonifen and benazolin) are poor performing. The development of the clearfield technology (Bojanich, 2003) has been the most important progress for weed control and sunflower No-Till area increase. Trials comparing weed control programs with imazapir applied at V4-V6 were successful (Rodriguez, 2005). Furthermore, since the introduction of CL sunflower hybrids up to date, genetic progress has been important on seed yield, oil content, and high oleic CL hybrids. For crop sequences in which participate corn and sunflower, CL sunflower usually follows corn, with excellent control of voluntary glyphosate resistant corn (Montoya et al., 2008). In modern conditions, a significant part of the above-mentioned elements of oilseed production technology is not adhered to and ignored. In particular, in recent years a sunflower has been returned to its original place after 2-3 years, and even earlier, while saving on fertilizers and plant protection products. All these negative factors lead to a significant loss of the yield, decrease in its quality, and as a result to the fall of seed gross collection.

The objective of this research was to identify the most effective elements of sunflower growing technology, which ensure the maximum productivity and economic efficiency of growing oilseed crops in the Steppe of Ukraine.

MATERIAL AND METHODS

Experimental studies were carried out in 2011-2017 in the field experiments of the State enterprise of experimental farm "Dnipro" of the Institute of grain crops of National Academy of Agrarian Sciences of Ukraine according to the following schemes (Table 1-3).

Table 1. Options for application of biological active substances

Biologicals	Dose of application
Seed treatment with water before sowing (control 1)	-
Soil treatment with water before pre-sowing cultivation (control 2)	-
Seed treatment Agat-25 K	0.2 l / ha
Seed treatment EM-1	1.0 l / ha
Introduction into the soil EM-1	2.0 l / ha
Seed treatment Gumysol	400 g / t
Seed treatment Gumat potassium	400 g / t

Table 2. Effect of mechanical and chemical control for sunflower growing

Soil cultivation trials	Herbicides
	mechanized (control)
Surface plowing on 25-27 cm	mechanized (control) + manual weeding (control 2)
	without care (control 3)
	acetochlor.(harnes) -2.5 l / ha
	dual gold - 1.0 l / ha + hezagard - 2.0 l / ha
	frontier optima - 1.4 l / ha
Flat-cut loosening on 14-16 cm	mechanized (control)
	mechanized (control) + manual weeding (control 2)
	without care (control 3)
	acetochlor.(harnes) -2.5 l / ha
	dual gold - 1.0 l / ha + hezagard - 2.0 l / ha
Disking on 10-12 cm)	frontier optima - 1.4 l / ha
	mechanized (control)
	mechanized (control) + manual weeding (control 2)
	without care (control 3)
	acetochlor.(harnes) -2.5 l / ha
Zero cultivation (direct sowing	dual gold - 1.0 l / ha + hezagard - 2.0 l / ha
	frontier optima - 1.4 l / ha
	acetochlor.(harnes) -2.5 l / ha
	without care (control 3)
	mechanized (control) + manual weeding (control 2)

Table 3. Options of sowing depth and seed fractions

Depth of sowing, cm	Fraction number, cm
4.0-5.0	5.0-6.0
4.0-5.0	4.0-5.0
4.0-5.0	4.0-3.0
4.0-5.0	2.5-3.0
4.0-5.0	<2.5
8.0-9.0	5.0-6.0
8.0-9.0	4.0-5.0
8.0-9.0	4.0-3.0
8.0-9.0	2.5-3.0
8/0-9/0	<2/5

The soil of the experimental plots was ordinary heavy-loamy chernozem. Topsoil is characterized with 4,2% humus, nitric nitrogen $\text{NO}_3\text{-N}$ 13.2 mg / kg, mobile forms of phosphorus and potassium 145 and 115 mg / kg respectively.

Unfavorable weather conditions for corn cultivation were in 2012. The hydrothermal coefficient (HTC) during the period of the largest water consumption of plants (the end of May - July) was equal to: 2011 – 0.8, 2012 – 0.6, 2013 – 0.7, 2014 – 0.9, 2015 – 0.8, 2016 – 0.9, 2017 – 0.8. The parameter of the HTC of less than 0.7 indicates the presence of soil and air drought, which negatively affects the formation and pouring of seeds.

RESULTS AND DISCUSSION

The external form of sunflower plants (*habitus*) play great importance in the process of yield formation. Sunflower seeds of the Middle Russian ecotype are grown in Ukraine. These plants have a height of 120-190 cm, do not branch, the seeds are shellfish. The average daily growth of the stem from germination to the formation of two pairs of real leaves is 0.8-1.0 cm, to the formation of baskets - 1.5-1.7 cm, to flowering – 3.0-4.3 cm. The upper part of the stem with a basket in most varieties is dying with an increase in the weight of baskets.

An important element in the formation of sunflower productivity is the number of leaves on a plant, which is often different even within a single hybrid. In particular, there are 24-28 units, and the mid-ripening - 28-32 units in early-ripening ones. The first pair of real leaves appears on the second or third day after appearing on the surface of the siblings, the next one - every two or three days. Death of plant leaves due to unpredictable cases (hail, drying out during a drought) usually leads to a decrease in its yield (Tkalic et al, 2018). The removal of 50% of leaves in the flowering phase reduced the seed yield by 72% in our experiments.

The formation of baskets in early-ripening hybrids starts at three to four, in medium-late - at five to eight pairs of leaves. Unfavorable conditions in this period lead to a decrease in plant productivity due to the reduction in the number of colors in the basket. Under the influence of high temperatures, drought or rain in the center of the basket seeds are often not formed, and the lack of the harvest can reach 5-78%.

The above negative factors of influence of drought and other negative factors can be partially leveled using modern adaptive and drought resistant oilseed hybrids. It is very important to choose hybrids, adapted to the growing zone with a potential yield of not less than 4.0 t / ha with a high resistance to diseases, pests and sunflower broomrape (*Orobanche cumana* Wallr.).

Such hybrids of domestic breeding as “Limit”, “Charodii”, “Basalt”, “Anthracite”, “Sonahro”, “Sibson”, “Forward”, “Rurik”, “Zorepad”, “Oreol” are highly appreciated. The performance indicators of individual registered hybrids are shown in Table 4. High drought resistance of sunflower is achieved due to the formation of a well-branched root system. So, according to our observations, individual plant roots penetrate into the soil to a depth of 3 meters, and in the horizontal direction - to 1.5-1.7 m.

Table 4. Characteristics of sunflower hybrids of Ukrainian breeding

Hybrid	Plant height, cm	Vegetation period, days	Oil content, %	Potential yield, t/ha
Time	165	98	49	4.0
Rubikon	160	98	51	3.9
Sonahro	155	99	53	4.4
Sibson	165	99	50	3.9
Yason	180	108	50	4.2
Rurik	160	101	51	4.1
Queen	175	107	49	4.4
Slavson	165	110	50	4.1
Selianin	150	112	53	4.3
Suchasnyk	170	110	50	5.0
Husliar	165	112	52	5.1
Siuzhet	160	111	51	4.2
SSD _{0,95} , t/ha				0.09

It should also be noted that hybrids that are insufficiently resistant to diseases are not suitable for sowing, because this leads in some years to a significant loss of seed yield. Hybrids that are resistant to diseases phomopsis (*Phomopsis helianthi*), sclerotinia (*Sclerotinia sclerotiorum* (Lib.)), downy mildew (*Plasmopara halstedii*), phomasum (*Phoma oleracea* var. *Helianthi* Sacc.), rust (*Puccinia helianthi* Schw.) can be returned to their original place even earlier than the recommended period, namely, in 4-5 years, but provided that after harvesting (Tsyliuryk et al., 2017, 2018). It is necessary to conduct a deep surface plowing on 27-32 cm, wrapping crop residues with pathogens in the soil. If black fallow is planned after the sunflower, it is possible to carry out a surface cultivation (6-8 cm) in the spring so that pathogens die on the soil surface under the influence of unfavorable environmental factors (light, precipitation, temperature changes, etc. This is possible with good soil water availability, absence of plant diseases in the year of harvesting sunflower seeds and application of fertilizers.

In addition to the right choice of hybrids in growing sunflower, the main cultivation of the soil is also very important. As a rule, soil cultivation under the sunflower in different farms, depending on cultivation conditions, is differentiated. That is why, they perform deep surface plowing or chiseling at a depth of 25 - 27 cm, non-surface flat-cut loosening at 20-22 cm, as well as shallow plowing (disking) by 10 - 12 cm (Table 5).

The obtained scientific data show an increase in weediness and a decrease in the yield on a descending scheme: deep surface plowing - chiseling - flat-cut loosening - shallow disking - No-till system. First of all, it is caused by deterioration of the physical state of the soil, moisture and nutrition regimes, phytosanitary conditions, etc. (Tsyliuryk, 2018). Sunflower reacts well both to to macroelements

and the introduction of trace elements and bacterial agents. High increments in seed yield are provided by the treatment of seed material and the introduction into the soil of biologically active substances and bacterial agents. (Figure 1).

Table 5. Sunflower yield depending on soil cultivation and herbicides (average for 2010-2012).

Options for weed control	Yield according to treatments, t/ha			
	Surface plowing at 25-27 cm	Flat-cut loosening at 14-16 cm	Shallow disking at 10-12 cm	Direct sowing + roundup
Mechanized treatment (control)	2.39	2.19	1.91	–
Manual weeding (control 2)	3.24	2.93	2.62	2.43
Without treatment (control 3)	1.6	1.35	1.21	1.91
Harnes, 2,5 l/ha	3.05	2.30	2.33	1.78
Dual gold, 1,0 l/ha +hezagard, 2,0 l/ha	3.06	2.50	2.11	1.61
Frontier optima, 1,4 l/ha	3.04	2.60	2.19	1.77
Average	2.72	2.31	2.06	1.70
SSD _{0,95} t/ha		0.09-0.11		

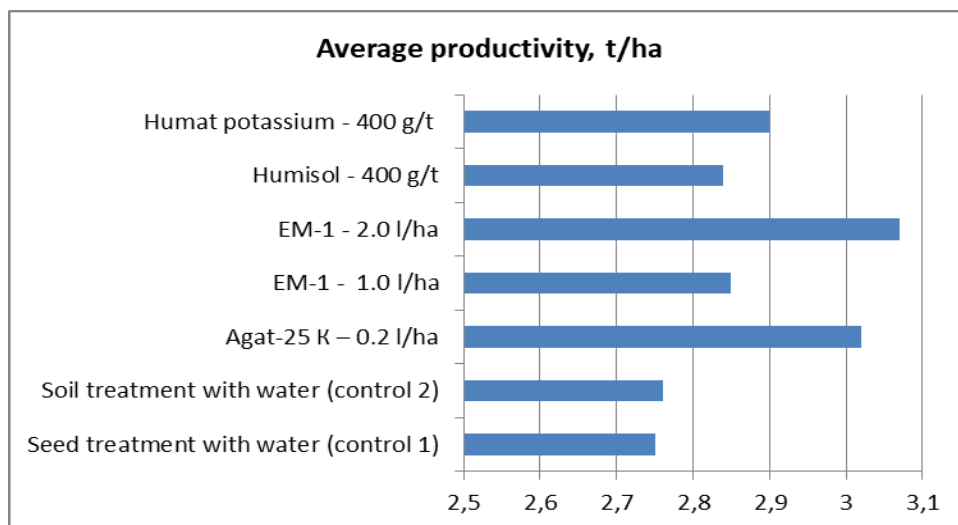


Figure 1: Effectiveness of biological active substances for sunflower yield (in average for 2013-2015).

The sunflower yield increase from their application varies within 0.09-0.32 t / ha, or 3.2-10.4%, and the maximum increase was found applying EM-1 into the soil.

An important element in the technology of sunflower growing is also the right choice of high quality seed material, which should have a similarity of at least 85%. The sunflower is adapted practically to an unlimited reduction of all organs, both vegetative and generative, including seed sizes, while preserving the reproduction function. The difference in the yield of oilseed sunflower in the next generation from seeds of different sizes is practically in focus of current tasks. The three years field experiments data to see optimum depth for different fractions of sunflower hybrid “Enei” are shown in the table 6.

Table 6. Influence of seed size on the yield of sunflower hybrid “Enei” (in average for 2008-2010).

Sunflower seeding depth, cm	Fraction №	Weight of 1000 sown seeds, g	Yield, t/ha
4-5	1	92.2	2.65
	2	53.3	2.60
	3	33.3	2.62
	4	28.6	2.55
	5	21.7	2.50
8-9	1	92.2	2.82
	2	53.3	2.68
	3	33.3	2.63
	4	28.6	2.64
	5	21.7	2.45
SSD _{0,95} , t/ha			0.07

Sowing small seeds is economically more profitable than large ones, because in order to obtain friendly germs, it requires less moisture in the soil. Better result was obtained for fraction №1. Small seeds can be sown to a depth of 8-9 cm in moist soil.

It is established that the main task of a pre-sowing tillage in the spring under the sunflower is the qualitative and optimal loosening of the sowing layer of the soil, which provides uniform seeding, contributes to the moisture preservation, the destruction of weeds and improves biological activity of the soil. In recent years, agricultural producers in Ukraine have been paying more attention to sunflower growing, due to high and attractive price of oilseed crops that grows each year (Tsyliuryk, et al., 2018). There are a lot of reserves for the further increase of the sunflower yield (Sessiz et al., 2008). One of the tasks in this direction is the elimination and leveling of the violations of the oilseed production technology, in particular, placing after the best predecessors and observance of the sunflower return policy to the original place in 5-6 years, selection of the best hybrids that are adapted to the environmental conditions,

application of optimal doses of micro and macro fertilizers, plant growth regulators, pest and disease control, compliance with all technological regulations in the care of crops, etc (Malhi et al., 2006; Heidari et al., 2008).

In conditions of late growth with a rapid increase in temperature, when the soil is leveled and not compacted, and the field is weakly overgrown with weeds, it is possible to be limited just to spring harrowing and one pre-sowing cultivation. On the untreated areas from the autumn, it is reasonable to carry out only shallow soil cultivation, using combined aggregates, disk harrows and cultivators, since spring surface tillage helps to re-dry the soil to the cultivated depth. Soil fertilization is also an important reserve for increasing the yield of sunflower seeds. The sunflower also reacts well to the result of the fertilizer introduced under the predecessor or before predecessor.

It should be noted, taking into account all mentioned reserves for increasing sunflower yield, that scientific investigations on studying their effectiveness are always relevant and should be constantly carried out due to changes in the climatic conditions of the terrain, the diversity of soils, the emergence of new technologies, hybrids, biological preparations, herbicides, fertilizers, modern machinery samples, etc. Correct selection of technological measures necessarily should be focused on energy conservation and saving material resources and time. Scientifically grounded application of technological measures for growing sunflower can significantly increase the yield of oilseed crops even by 25% or more without significant material costs and damage to the environment.

CONCLUSIONS

High productivity adaptive hybrids resistant to diseases and pests, should be used for sowing. The highest yields of sunflower hybrids are provided when plants are placed after surface plowing and chiseling at a depth of 25-27 cm. Reducing the depth of cultivation to 10-12 cm and direct sowing in untreated soils leads to a significant decline in sunflower yield by 20-30%. An important factor in increasing the crop yield is the use of fertilizers ($N_{40}P_{60}K_{30}$), which is better during the basic soil treatment in the autumn or under pre-sowing cultivation, which provides an increase in the yield of seeds at a level of 0.2-0.4 t / ha. High efficiency in the technology of sunflower growing is also provided by the use of physiologically active substances. The yield increasing from their application varies within 0.09-0.32 t / ha or 3.2-10.4%.

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