Fuchylo, Y., Makukh, Y., Remeniuk, S., Smolkova, N., Kharytonov, M. (2020): Weed control during the first vegetation of black poplar (Populus nigra L.) plantation. Agriculture and Forestry, 66 (1): 171-177.

DOI: 10.17707/AgricultForest.66.1.16

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WEED CONTROL DURING THE FIRST VEGETATION OF BLACK POPLAR (*POPULUS NIGRA* L.) PLANTATION

SUMMARY

Black poplar (*Populus nigra* L.) is fast-growing species, demanding in terms of light and soil and very sensitive to weeds, especially in the first vegetation. Therefore, developing effective, environmentally friendly weed control measures is an urgent task for herbologists. There is an inverse relationship between the amount of weed mass and the productivity of black poplar; the lowest height, biomass yield and energy yield (87.1 cm, 0.41 t/ha and 8.06 GJ/ha, respectively) were found in the control treatment with the highest weed mass accumulation (3062 g/m^2). The practice of mechanical weed control influenced the accumulation of weed mass in the black poplar plantations. Three consecutive cultivations of interrow space and three consecutive harrowing sessions at an interval of 14 days reduced weed mass 2.7 times. Soil mulching with sawdust almost completely destroyed the weeds in the experimental plots.

Keywords: poplar, average productivity, weed infestation, leaf area.

INTRODUCTION

Poplar (*Populus spp.*) is undoubtedly one of the most promising bioenergy crops due to very fast growth and ability to produce more than 15 m^3 of wood in a short time (Berguson et al., 2010). There are up to 4.0 million hectares of unproductive agricultural land suitable for energy trees cultivation in Ukraine. The cultivation of energy wood on plantations, in particular, the representatives of *Populus* L., has been studied relatively recently In Ukraine (Vysotska, 2016; Kharytonov et al., 2017). Energy plantations will facilitate the rational use of the country’s land resources. Poplar biomass has been used in EU countries as a feedstock for the production of bioethanol and pellets for house heating at least last decade (Branco et al, 2019; González - García and Bacenetti, 2019). Poplar trees are distinguished from other tree species by many valuable biological features. Firstly, they grow very fast. Poplar trunks are suitable for cellulose

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Notes: The authors declare that they have no conflicts of interest. Authorship Form signed online.
Received:23/11/2019 *Accepted:27/02/2020*

production already in 20 years (Klasnja et al., 2012; Karacic et al., 2006). Secondly, the possibility of easy vegetative multiplication using winter stem cuttings, root cuttings, and root shoots as well as easy seed reproduction. Thirdly, easy natural and artificial, intro - and interspecific hybridization that facilitates the production of new fast - growing clones (Kutsokon et al., 2014). Poplar is common in forests throughout the Northern Hemisphere in both temperate and subtropical zones (Kutsokon et al., 2014). Mostly it occurs in North America and Eurasia (Panacci et al., 2009; Labrecque and Teodorescu, 2005; Karacic and Weih, 2006). Today, Canada is one of the leading countries in the world for the production and use of poplar wood biomass (Labrecque and Teodorescu, 2005). Its use as the secondary energy source in the country increased from 3.5% in 1970 to 6.5 % (Dickmann, 2006). Plant survival and intensive growth of new poplar plantations are affected by weed competition (Kauter et al., 2003). It was shown the importance of weed control in the first year of energy trees cultivation regardless of the genotype and growing conditions (Broeckx et al., 2012; Albertsson et al., 2014).

Weeds in poplar planting are strong competitors for water, nutrients, and light. Aboveground competition affects the morphological and physiological features of plants, such as leaf area, plant height, and biomass, photosynthetic activity, which directly or indirectly affects the ability of plants to consume light (Balandier et al., 2006). Underground competition, above all, for nutrients and water is more important and has a greater impact on the growth and development of both cultivated plants and weeds. In this case, there is a more complex mechanism of root system activity that involves such soil properties as density, structure and microorganisms community (Phillips et al., 2014; Caldwell et al., 1986; Casper and Jackson, 1997). As a result of competition with weeds, a decrease in growth of more than 50 % and an increase in the die-off rate of trees in plantations are observed (Thompson and Pit, 2003). Therefore, it is urgent to substantiate a competitive power of black poplar plantings and to develop an effective weed control system for the Right-Bank Forest Steppe of Ukraine.

The main objective of this study was to evaluate the efficiency of available environment-friendly mechanical and environmental weed control practices for black poplar.

MATERIAL AND METHODS

This case study was carried out from 2017 to 2018 in field experiment at the Salyvinky Experimental Farm of the Institute of Bioenergy Crops and Sugar Beet NAAS (IBCSB) in Ksaverivka village, Vasylkiv District, Kyiv Region located in the zone of unstable soil water supply of the Central Forest Steppe of Ukraine, with the moderately continental climate. The soil for the experiment was meadow chernozem or molisols (Kravchenko et al., 2012). Complete cultivation was carried out before planting. One-year black poplar cuttings of 25 cm in length were planted in the middle of April. Planting design was 150 cm x 75 cm x 75 cm. The distance between the plants in a row was 0.59 cm. Plant density was 15,000 per hectare. Sowing area was 50 m^2 and accounting area 25 m^2. The experiment was carried with three replicates. Weeds observation was carried out using fixed frames measured 1.25 m x 0.20 m = 0.25 m^2 that were permanently set in four places diagonally in each treatment (Tsyliuryk et al, 2017). The first and second registration of weeds was made in early May and second decade of August accordingly.

The yield of the above-ground part of plants was determined by the method of cutting the above-ground parts at the experimental sites and expressed in either g/m^2 or t/ha. The experiment was established in energy plantations of Salix viminalis in its first growing season according to the following design: (a) without weed treatment; (b) three consequent cultivations between rows at an interval of 14 days; (c) three consequent harrowing between rows using mounted chain harrow at an interval of 15 days; (d) three consequent manual weed cutting (cut height 1.5−3.0 cm at an interval of 14 days); (e) topsoil mulching with 15-cm sawdust layer; (f) six consequent hand weedings (to total destruction of weeds).

RESULTS AND DISCUSSION

At the time of the first records of the number of weeds observation, the dominating weeds were *Elymus repens* (L.) Gould (9.9), *Setaria glauca* (L.) P. Beauv (3.7), *Chenopodium album* L. (4.1), *Echinochloa crus-galli* (L.) P. Beauv (3.4) and other species. The total number of weeds averaged 33 units (Table 1).

Table 1: Weed infestation of black poplar stands, 2017−2018 (plant/ m^2)

Weed species	Date of counting				
	13.05	13.06	13.07	13.08	13.09
Echinochlea cruss-galli (L.) P. Beauv	3.4	21.3	22.4	22.6	22.5
Setaria glauca (L.) P. Beauv	3.7	22.8	29.3	29.8	29.8
Chenopodium album L.	4.1	5.7	7.9	8.5	8.5
Sinapis avrensis	2.2	6.2	7.7	8.0	8.0
Thlaspi avrense L.	2.1	8.4	9.8	10.0	10.1
Polygonum lapathifolium	1.3	1.3	2.8	3.3	3.3
Solanum nigrum	1.8	2.7	3.2	5.9	6.2
Elytrigia repens (L.) Gould	9.9	15.9	16.1	17.2	17.2
Other species	4.5	5.6	8.2	8.3	8.3
Total weeds	33.0	89.9	107.4	113.6	113.9

Weed mass accumulation in black poplar stands was significantly affected by an applied weed control practice (Table 2). Carrying out three cultivations of inter-row space at an interval of 14 days (treatment B), as well as three harrowing (treatment C), reduced the weed mass 2.7 times. Hand weeding (treatment D) reduced it 2.9 times. The application of a 15-cm layer of wood sawdust (treatment E) almost completely destroyed the weeds. Calculations of projective leaf area in one-year black poplar stands revealed very small values of this area, in the first half of the growing season especially. Average values of projective leaf area at the time of the first counting (13 May) showed that all weed species formed 28.3 % of the projective leaf area in total.

Table 2: The efficiency of mechanical weed control systems in black poplar stands on the value of weed mass accumulation, the average for 2017−2018 (g/m^2)

Weed species	Treatment					
	A	B	C	D	E	F
Echinochlea cruss-galli (L.) P. Beauv	322	114	121	111	-	-
Setaria glauca (L.) P. Beauv	218	101	103	97	-	-
Chenopodium album L.	611	232	217	230	-	-
Sinapis avrensis	237	81	79	85	-	-
Thlaspi avrense L.	211	46	41	43	-	-
Polygonum lapathifolium	187	65	66	61	-	-
Solanum nigrum	829	312	321	274	-	-
Elytrigia repens (L.) Gould	134	97	101	72	7	-
Other species	313	79	82	71	3	-
Total weeds	3062	1127	1131	1044	10	-
$LSD_{0.05}$	1.8					-

Poplar seedlings had not yet formed a significant projective coverage yet. It was less than 1 % (Table 3).

Table 3: Projective leaf area of weeds in black poplar stands, 2018 (%)

Weed species	Date of counting				
	13.05	13.06	13.07	13.08	13.09
Echinochlea cruss-galli (L.) P. Beauv	1.1	14.2	13.7	12.4	9.1
Setaria glauca (L.) P. Beauv	1.1	14.4	13.2	11.6	8.9
Chenopodium album L.	1.1	15.7	16.1	17.9	13.3
Sinapis avrensis	9.7	18.3	21.7	20.6	18.6
Thlaspi avrense L.	9.5	16.1	18.3	18.8	15.7
Polygonum lapathifolium	1.5	7.2	10.1	11.9	9.9
Solanum nigrum	1.1	2.9	3.1	4.1	3.7
Elytrigia repens (L.) Gould	1.3	6.3	2.6	1.7	0,8
Other species	1.9	4.9	1.2	1.0	0,9
Total weeds	28.3	100	100	100	80.9

As a result of the active processes of plant growth and development after 30 days, i.e. on 13 June, the situation in the field changed. Culture plants formed leaves and started forming new shoots. Their projective leaf area increased to 5 %. Wild plants filled all available ecological niches and completed projective cover to 100 %. The largest share in the formation of the projective leaf area was fixed among the next several weed species: *Sinapis avrensis* (18.3 %), *Thlaspi avrense* L. (16.1 %), *Chenopodium album* (L.) (15.7 %), *Setaria glauca* (L.) (14.4 %), *Echinochlea cruss-galli* (L.) (14.2 %), *Elytrigia repens* (L.) (6.3 %). Different intensity of weed infestation in the experimental plots significantly affected the growth rate of black poplar seedlings, biomass accumulation and then, in a consequence, energy yield (Table 4).

Table 4: The average productivity of black poplar under different weed control systems, 2016−2018

Parameter	Treatment						
	A	B	C	D	E	F	$LSD_{0.05}$
Shoot height (cm)	87.1	130.5	130.1	133.2	166.3	171.0	5.9
Yield (t/ha)	0.41	0.77	0.76	0.81	1.10	1.16	0.09
Energy yield (GJ/ha)	8.06	15.22	15.04	15.93	21.66	22.91	1.4

There is an inverse relationship between weed number and poplar productivity. Thus, the lowest values of height, biomass yield, and energy yield (87.1 cm, 0.41 t/ha and 8.06 GJ/ha, respectively) were found in the control treatment, where the highest amount of weed mass was found as 3062 g/m^2 (Table 2).

The plants of black poplar had approximately the same height (130.1−133.2 cm), dry biomass yield (0.76−0.81 t/ha) and energy yield (15.04−15.93 GJ/ha) in treatments B, C and D, where approximately the same weed mass amount (from 1044 to 1131 g/m^2) was measured. Similar results were obtained in our field experiments to see best weed control method in willow plantation (Fuchylo et al., 2019).

Treatment E, with the application of sawdust as mulch, provided almost complete destruction of the weeds (only 10 g/m^2 remained). This treatment result can be compared with treatment F after six consecutive weedings.

CONCLUSIONS

Black poplar, as a fast-growing, and demanding to light and soil crop, is very sensitive to weeds, especially in the first vegetation.

There is an inverse relationship between the amount of weed mass and the productivity of black poplar. Thus, the lowest values of height, biomass yield, and energy yield (87.1 cm, 0.41 t/ha and 8.06 GJ/ha, respectively) were found in the control treatment with the highest weed mass accumulation (3062 g/m^2).

The practice of mechanical weed control influenced on the accumulation of weed mass in the black poplar plantations. Three consecutive cultivations of interrow space and three consecutive harrowing at an interval of 14 days reduced weed mass 2.7 times. Soil mulching with sawdust almost completely destroyed the weeds in plots with poplar.

ACKNOWLEDGEMENTS

This study was supported by the National Academy of the Agrarian Sciences of Ukraine.

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