PROBLEM WEEDS CONTROL IN STRAWBERRY CROPS IN DIFFERENT GROWING SYSTEMS IN ROMANIA

Marga Grădilă*, Daniel Jalobă, Valentin-Marius Ciontu, Raluca-Monica Cristea

Research – Development Institute for Plant Protection, 8 Ion Ionescu de la Brad Blvd, 013813, Bucharest, Romania

Abstract

Irrespective of the growing system practiced, strawberry plants are very susceptible to weed competition, especially in the beginning stage after planting, when they are small and frequent irrigations provide perfect conditions for the weed seeds germination. Weeds emerged inside the cannopies, in perennial crops, negatively influence the longevity of the plantations by weakening the plants or even suffocating them, consuming water and nutrients, favoring the infection with diseases and pests, negatively influencing the ripening of the fruits. The research aimed the identification of problem weeds and measures to combat them in 3 different systems of perennial strawberry crops grown under field conditions. The research and assessments were carried out in Giurgiu County at Hotarele in the strawberry crop cultivated with plastic film in rows and straws substrate between the rows, in the village of Oinacu in the strawberry crop with plastic film in rows and in the experimental field at RDIPP - Bucharest where the strawberry was grown without film and without straws substrate between the rows. Two determinations were made on each row of strawberries in the period 2021-2022, using a metric frame and the observations concerned the density (number of plants/m^2), the participation (% in which each species participates in the general weeding), the frequency (% where each species was noticed at the observation points), family, class (monocotyledonous, dicotyledonous) and living period of each species. The growing system with plastic film on rows and with a layer of straws between rows ensured the best protection of the strawberry crop against the weeds competition, on condition that after harvesting the weeds that sprout through the holes of the film, on the interval between rows and around the strawberry field, to be destroyed.

Keywords: *strawberry, plastic film, weeds, herbicides*

1. INTRODUCTION

Weeds and especially the perennial species are persistent problems with limited management options for strawberry growers in Romania. Due to their small height, strawberries crops (*Fragaria* × *ananassa* L.) of *Rosaceae* family are easily overwhelmed by weeds and the damages caused by them are significant. The presence of weeds in strawberry crops leads to a substantial decrease in yield (Dragoş 2011, Sălceanu & Olaru 2016; Bucurean 2017, Yu & Boyd 2017). The control of weeds in strawberries is one of the most essential factors in strawberry production. Strawberry plants are easily overgrown by tall, rapidly growing weeds and, in a few weeks, they may be severely damaged (Scott et al. 1954, Chirilă 2001, Fennimore et al. 2003; Berca 2004). Weeds grown inside strawberry bushes, in multiannual crops, negatively influence the duration of the estates by weakening plants or even suppressing them, consuming water and nutrients from the root area, and they are hosts for some diseases and pests. A wet environment is maintained inside the bushes for a longer period of time, both following rainfall and in the morning when dew lasts longer, which is favourable to the emergence and development of grey mold (*Botrytis cinerea*) (Agamalian et al. 1994; Lange 1985; Sălceanu & Olaru 2016; Maxim, et al. 2019). Because of shading caused by weeds, fruit ripening is also negatively affected.

The technology of field tillage and crop establishment, based on organic fertilisation, favours an increase in the weed seed bank, with monocotyledonous annual species predominating in many areas: barnyardgrass [*Echinochloa crus-galli* (L.) P. Beauv.], foxtail [*Setaria* spp. (L.) Beauv.], crabgrass [*Digitaria sanguinalis* (L.) Scop.] etc. Among perennial monocotyledonous weeds, quackgrass [*Agropyron repens* (L.) Beauv.] and johnsongrass [*Sorghum halepense* (L.) Pers.] cause great loss in

areas where they are occurred and they are difficult weeds to fight off. The following dicotyledonous species are commonly found: common lambsquarters (*Chenopodium album* L.), chamomile (*Matricaria chamomilla* L.), wild mustard (*Sinapis arvensis* L.) common chickweed [*Stellaria media* (L.) Vill.], common knotweed (*Polygonum aviculare* L.) shepherd's-purse {*Capsella bursa-pastoris* (L.) Medik.], common groundsel (*Senecio vulgaris* L.), field bindweed (*Convolvulus arvensis* L.), creeping thistle [*Cirsium arvense* (L.) Scop.] etc. The tremendous pressure of perennial species can lead to a totally strawberry crops damage. The maximum density of weeds in strawberry crops occurs in May-June, when the strawberry is in the fruit formation and ripening stages, therefore manual and mechanical work to control them would lead to quantitative and qualitative depreciation of the fruits.

Mechanical and manual weed control after fruit harvesting and mowing of the leaf area, which is practised in multiannual crops, is also difficult because weed growth rate is very fast and the bushes are quickly smothered. Therefore, the fight against weeds in strawberry crops must be carried out permanently and by all means: mechanical, manual and chemical in order to obtain high yields and very good quality.

Chemical control is a modern method that is continuously expanding and is technically and economically efficient. In order to prevent strawberry crops from weed infestation immediately after planting, to keep the crop clean throughout its life and to destroy as wide a range of weeds as possible with as little work as possible, a strategy for chemical weed control and mechanical weed control must be developed as soon as the crop is established. This strategy is also necessary due to the fact that each herbicide has a certain spectrum of action, sometimes restricted, and it is mandatory to use several herbicides at different times of the year for this work to be effective. For these reasons, weed control in strawberry crops should start with the land tillage for crop establishment. The farmer must know the weed species in advance to avoid ineffective herbicide treatments that do not match the existing weed spectrum. Thus, about three weeks after ploughing and harrowing, when the weeds that have emerged are 10-15 cm high, the field is treated with a total herbicide. Pre-emergent herbicides to be incorporated are applied before the stolons are planted (about 5 cm deep) and the ones that form a film on the soil surface immediately after planting. This film should not be broken by tillage. During growing season, if necessary, postemergence herbicide treatment is applied to control the emerged weeds. If weeds are not destroyed by herbicides applied throughout the time of vegetation, these will be weeded by hand. Existing herbicide choices in strawberries are limited (Manning & Fennimore 2001). In this context, the research aimed the identification of problem weeds and measures to control them in 3 different systems of perennial strawberry crops grown under field conditions.

2. MATERIALS AND METHODS

The research and assessments were carried out in Giurgiu County at Hotarele in the strawberry crop cultivated within plastic film in rows and straws substrate between the rows, in the village of Oinacu in the strawberry crop with plastic film in rows and in the experimental field at RDIPP - Bucharest where the strawberry was grown without film and without straws substrate between the rows. The experiments were conducted in 2021-2022, in randomized complete blocks design, with plot area of 20 m^2, in four repetitions. Each plot included 4 rows of strawberry with 10 plants per row. Each experimental block included an untreated plot.

Three herbicides from different chemical groups were tested: Dual 960 EC (960 g/L S-metolachlor) from the chemical group of chloracetamides applied at the rate of 0.8, 1.0 and 1.2 l/ha, Sultan 50 SC (500 g/L Metazachlor) from the group of chloroacetanilide applied at rate of 0.5 l/ha and Sharpen 40 SC (400 g/L Pendimethalin) from the chemical group of dinitroaniline applied at rates of 3.0, 3.5 and 4.0 l/ha. The herbicides were applied pre-emergent at the end of March before the start of the strawberry stolons in the vegetation in 300 liters of water per hectare when the weeds were not emerging.

Two determinations were made on each row of strawberries in the period 2021-2022, using a metric frame and the observations concerned the density (number of plants/m^2), the participation (% in which each species participates in the general weeding), the frequency (% where each species was noticed at the observation points), family, class (monocotyledonous, dicotyledonous) and living period of each

species. The herbicide treatment was done with pump with nozzles for plot trails. The herbicide efficacy was recorded on the 10th, 20th and 30th day after treatments by the 10 scores scale for efficacy of EWRS (European Weed Research Society), in % control compared to untreated plots. Also, observations were done on the weeds found in the experimental plots before treatment, and on selectivity - at each date of the efficacy assessments. In each trial, herbicide phytotoxicity was rated visually - at each date of the efficacy assessments on a 0-10 scale (0: no visible injury; 10: plant death). Weed density was assessed in ground % and in number of plants per square meter. Determination of segetal flora was performed on one square meter using a metric frame. Statistical data - processing of the assessments was based on the analysis of ARM-9 software (P = .05, Student - Newman - Keuls).

3. RESULTS AND DISCUSSION

The observations made in the strawberry plantation in the Hotarele village, showed that the growing system with plastic film on rows and with a layer of straws between rows ensured the best protection of the strawberry crop against the weeds competition, on condition that after harvesting the weeds that sprout through the holes of the film, on the interval between rows and around the strawberry field, to be destroyed. After harvesting, few species of weeds with a with a density of less than 4 plants/m^2 were identified: *Setaria, Echinochloa, Amaranthus,* which did not cause problems in terms of competition with strawberry plants. In the growing system covered by plastic film on the rows but without straws layer between the strawberry rows at Oinacu village, the following species were noted: common purslane (*Portulaca oleracea* L.), the green foxtail [*Setaria viridis* (L.) Beauv.], common lambsquarters (*C. album*), pigweed (*Amaranthus retroflexus* L.), barnyardgrass (*E. crus-galli*), common chickweed (*S. media*), shepherd's-purse (*C. bursa-pastoris)*, henbit deadnettle (*Lamium amplexicaule* L.) and common field speedwell (*Veronica persica* Poiret).

From the analysis of the data presented in Figure 1, it is noted that the dominant weeds in the experimental field were the annual dicot species with a density higher than 65% in the control variant 30 days after the application of herbicides. Among the species with a low density per square meters (other species) were present: dandelion (*Taraxacum officinale* G. H. Weber ex Wiggers) sowthistle (*Sonchus arvensis* L.) stinging nettle (*Urtica dioica* L.), peppermint (*Mentha* x *piperita* L.), willow weed (*Polygonum persicaria* L.) and large crabgrass *D. sanguinalis*.

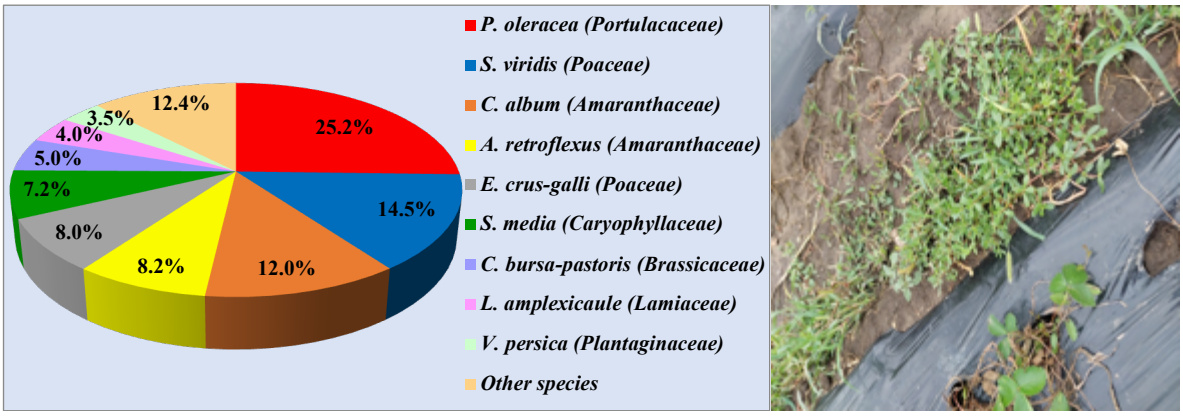

Figure 1. Weeds density after 30 days after treatment at Oinacu, Giurgiu county

In these conditions of weed infestation, the herbicides applied had a good effectiveness in controlling annual weeds in the strawberry crop without straw between the rows (no mulching) the best results being obtained at higher doses (Table 1). Thus, for Dual Gold 960 SC at the rate of 1.2 l/ha the effectiveness was*: P. oleracea* 90.9%, *S. viridis* 94.7%, *C. album* 92.5%, *A. retroflexus* 90.9%, *E. crus-galli* 96.1%, *S. media* 96.1%, *C. bursa-pastoris* 100%, *L. amplexiacaule* 97.4% and *V. persica* 97.4%. S-Metolachlor works by inhibiting the growth of long-chain fatty acids of target weeds. This results in a halt in the

growth of seeding shoots which causes the weed to not germinate and sprout out of the soil. For the herbicide Sharpen 40 EC at 4.0 l/ha the effectiveness was: *P. oleracea* 100%, *S. viridis* 97.4%, *C. album* 96.1%, *A. retroflexus* 92.5%, *E.crus-galli* 80.5%, *S. media* 97.4%, *C. bursa-pastoris* 100%, *L. amplexiacaule* 97.4 and *V. persica* 100%, at 30 days after treatment.

The active substances, Pendimethalin inhibits root and shoot growth. It controls the weed population and prevents weeds from emerging, particularly during the crucial development phase of the crop. Its primary mode of action is to prevent plant cell division and elongation in susceptible species.

The herbicide Sultan 50 SC applied at 0.5 l/ha had a lower effectiveness in comparison with S-Metolachlor and Pendimethalin in control of weed in strawberry crop at Oinacu village: *P. oleracea* 57.6%, *S. viridis* 62.6%, *C. album* 62.9%, *A. retroflexus* 57.6%, *E. crus-galli* 72.6%, *S. media* 67.8%, *C. bursa-pastoris*75.1%, *L. amplexiacaule* 75.0% and *V. persica* 60.2%, at 30 days after treatment. The active substances Metazachlor acts primarily by inhibition of the formation of very-long chain fatty acids in lipid biosynthesis, through interaction with the condensing elongase enzyme system.

The predominant species was *P. oleracea*, an annual plant of the *Portulacaceae* family, native to Southern Europe and Middle East. In Romania it is also known as graşiţă. The success of this plant is due to the fact that it matures quickly and produces a large number of seeds in favorable conditions (>240.000 seeds/plant), which retain their germinative properties for 3 - 4 years.

Table 1. The efficacy of herbicides in strawberry crops after 30 days of treatment (Oinacu – Giurgiu)

Treatment name	Dose l/ha	Efficacy (% control compared with the untreated plots)								
		Weeds stage majority (BBCH)								
		41-49	43-50	49	49	41-51	60-65	60-63	60-67	65-69
		POROL	**SETVI**	**CHEAL**	**AMARE**	**ECHCG**	**STEME**	**CAPBP**	**LAMAM**	**VERPE**
Untreated		0.0f	0.0d	0.0d	0.0c	0.0c	0.0d	0.0d	0.0d	0.0e
Dual Gold 960 SC	0.8	55.1e	62.6c	61.3c	57.6b	70.2b	65.4c	77.5c	75.1a	60.2d
	1.0	71.1b	78.9b	75.9bc	71.1b	80.5b	86.4b	85.3c	85.3b	81.0c
	1.2	90.9a	94.7a	92.5a	90.9a	96.1a	96.1a	100a	97.4a	97.4b
Sultan 50 SC	0.5	57.6b	62.6c	62.9c	57.6b	72.6b	67.8c	75.1c	75.0b	60.2d
Sharpen 40 EC	3.0	60.4de	70.2bc	67.9c	67.9b	80.5b	80.5bc	82.7b	85.2b	70.5d
	3.5	75.9c	81.2b	78.3b	70.2b	97.4a	80.5bc	97.4a	97.0a	85.3c
	4.0	100a	97.4a	96.1a	92.5a	80.5b	97.4a	100a	97.4a	100a
LSD P=Various		**1.4-11**	**5.8-12**	**6.0-11**	**7.0-10**	**5.3-10**	**6.5-13**	**0.9-7.8**	**4.5-8.7**	**0.9-9.3**
Standard Deviation		**4.6t**	**5.2t**	**4.7t**	**4.4t**	**4.8t**	**5.6t**	**3.7t**	**4.1t**	**3.8t**

Legend: 41- Flag leaf sheath swollen (late-boot); 49 -Constant new development of young plants;

43 - Flag leaf sheath just visibly swollen (mid-boot); 50 - First awns visible;

51 - Inflorescence or flower buds visible; 60 - First flowers open (sporadically);

63 - 30% of flowers open; 65 - Full flowering: 50% of flowers open, first petals may be fallen;

67 - Flowering finishing: majority of petals fallen or dry; 69 - End of flowering: fruit set visible.

In the experimental field without plastic film and without straws layer between the rows, the strawberry crop was compromised due to the presence of *C. arvensis* (Figure 2) an aggressive perennial species that endangered the crop, suffocating the strawberry plants (Table 2). There were also found: *S.*

halepense, *P. oleracea*, *C. arvense*, *Setaria* spp., wild carrot (*Daucus carota* L.) and velvetleaf (*Abutilon theophrasti* Medik.).

Figure 2. Aspects from the experimental fields.

Table 2. Weeds flora in strawberry crops, RDIPP Bucharest, 2022

Species	**Average no./m²**	**P (%)**	**F (%)**	**Family**	**Order**	**Life period**
C. arvensis	51	38.0	100	*Convolvulaceae*	*Solanales*	perennial dicots (i)*
S. halepense	20	14.9	100	*Poaceae*	*Poales*	perennial monoc. (i)*
P. oleracea	10	7.6	25	*Portulacaceae*	*Caryophyllales*	annual dicots
Setaria spp.	9	6.7	25	*Poaceae*	*Poales*	annual monocots
C. arvense	9	6.7	20	*Asteraceae*	*Asterales*	perennial dicots
D. carota	8	5.9	20	*Apiaceae*	*Apiales*	annual, biennial,
A. theophrasti	6	4.8	15	*Malvaceae*	*Malvales*	annual dicots
Weeds with density: 2-5 plants/m²						
V. persica	5	3.7	10	*Plantaginaceae*	*Lamiales*	biennial dicots (i)*
C. b.-pastoris	4	2.9	10	*Brassicaceae*	*Brassicales*	biennial dicots
S. media	4	2.9	5	*Caryophyllaceae*	*Caryophyllales*	annual dicots
S. oleraceus	4	2.9	5	*Asteraceae*	*Asterales*	annual dicots
A.artemisiifolia	2	1.5	5	*Asteraceae*	*Asterales*	annual dicots (i)*
S. arvensis	2	1.5	5	*Brassicaceae*	*Brassicales*	biennial dicots
Total	134	100	-			

*(i) - invasive species in Romania

From the analysis of the data presented in table 2, it can be seen that in the experimental field from RDIPP - Bucharest, 13 weed species were present with an average density of 134 plants/m² in the untreated after 30 days of the treatment. Perennial weeds that are difficult to control have dominated the soil with a density of 80 plants/m² and a percentage of participation in the total weeding of the strawberry crop >60%. In these conditions of weed infestation, the results obtained were disappointing, so as it was

necessary to apply a total herbicide in autumn after mowing the strawberry plants (Table 3). The presence of the species *C. arvensis* with a density >50 plants/m^2 and *S. halepense* with a density >20 plants/m^2 proved to be extremely harmful for the strawberry crop. Thus, for Dual Gold 960 SC at 0.8 l/ha (the lowest dose tested) the effectiveness was: *S. halepense* 33.5%, *C. arvense* 28.0% and *C. arvensis* 28.5%. The herbicide Sultan 50 SC applied at 0.5 l/ha had a lower effectiveness in perennials weed control in strawberry crop: *S. halepense* 33.6%, *C. arvense* 28.2% and *C. arvensis* 28.0% at 30 days after treatment.

Table 3. The efficacy of herbicides in strawberry crops after 30 days of treatment (RDIPP – Bucharest)

Treatment name	**Dose L/ha**	**Efficacy (% control compared with the untreated plots)**						
		Weeds stage majority (BBCH)						
		41-51	49-50	49-55	44	49-55	49-60	49-55
		SORHA	**SETSS**	**CIRAR**	**POROL**	**DAUCA**	**ABUTH**	**CONAR**
Untreated		0.0d	0.0d	0.0c	0.0c	0.0d	0.0c	0.0c
Dual Gold 960 SC	0.8	33.5c	67.5c	28.0b	73.8b	67.5c	44.8b	28.5b
	1.0	41.3b	80.5bc	35.6ab	94.7a	80.5bc	52.5ab	37.2ab
	1.2	48.7a	92.5ab	47.3a	97.3 a	92.5ab	60.2a	44.7a
Sultan 50 SC	0.5	33.6c	67.6c	28.2b	73.9b	67.8c	44.9b	28.0b
Sharpen 40 EC	3.0	41.2b	80.5bc	35.7ab	74.0b	80.6bc	52.6ab	37.4ab
	3.5	49.0a	86.4b	45.9a	90.5 a	86.4b	60.0a	45.0a
	4.0	50.0	97.4a	46.0a	97.0a	97.4a	60.2a	47.7a
LSD P=Various		**6.0-6.2**	**8.0-14.6**	**10-11.3**	**7.9-13.2**	**8.0-14.6**	**7.5-7.6**	**9.7-10.2**
Standard Deviation		**2.3t**	**6.5t**	**4.2t**	**6.4t**	**6.5t**	**2.8t**	**3.8t**

Legend: 55 - First individual flowers visible (still closed).

Field bindweed is a persistent perennial weed in the *Convolvulaceae* family found on cultivated fields, orchards, plantations, pastures, lawns, gardens, roadsides and along railways. It is listed as one of the ten most serious weed problems worldwide. Its extensive, competitive root system is capable of vegetative reproduction. This combined with long-lived seeds makes it difficult to manage. Dense tangled mats formed from the trailing vines, and vines climbing on crops, reduce crop yields and increase production costs. Over 500 seeds per plant can be produced from the funnel-shaped flowers. Once established, field bindweed will persist after most control applications. On croplands, frequent cultivations will reduce root reserves; however, infestations can increase under no-till or reduced till management. Cultivation combined with application of 2, 4-D, glyphosate, or their combination will reduce field bindweed without injury to crops. Dicamba, glyphosate, picloram, quinclorac and 2, 4-D will provide short-term suppression of field bindweed (Westra et al. 1992, Jacobs 2007; Davis et al. 2018). *C. arvensis* causes special problems because of its ability to reproduce both through seeds but particularly through vegetative propagation, and also because it's relative tolerance to numerous herbicides (Teodor et al. 2013). In Romania, it is found everywhere, on all soils, and particularly on warm, drier, light and permeable soils, on road sides, in vegetable gardens, where it suffocates young seedlings, in nurseries and plantations, where it clings on shrubs. In ornamental gardens, it clings to roses and other decorative plants. On loose grassy soles, it clings to gramineae and hinders their growth.

It is a mesophilous plant drought-resistant due to its deep root system, but it cannot stand frost. It is a very damaging weed for crops (Fritea et al. 2008; Culhavi & Manea 2011). No phytotoxicity symptoms have been shown in experimental plots. No symptoms of chlorosis, necrosis, leaf deformation, height reduction, distortion and delay at flowering in plots treated with Pendimethalin were seen (OEPP/EPPO Standards Bulletin, 2014). Also, in experimental plots with strawberry crops there were present the invasive species *A. artemisiifolia, S. halepense* and *V. persica* that, when under favourable conditions of growing and development, can cause great damage and pose serious challenges in control (Grădilă & Jalobă, 2017; Grădilă et al., 2020). Invasive plants frequently have competitive advantages over native species. This is also the case of the species *S. halepense* identified in strawberry crops without mulching, ranked among the worst and extensively disseminated weed species. It is emerging as a potential menace for agroecosystems in 53 different countries across the world. This weed is adapted to warmer regions and is native to Mediterranean areas of Africa, Asia and Europe (Follak & Essl 2013; Rout et al. 2013; Peerzada et al. 2017). Infestation with perennial weeds resulted in the total compromise of the strawberry crop without plastic film and without straws layer between the rows.

4. CONCLUSIONS

The maximum density of weeds in strawberry crops is achieved in May-June, when the strawberry is in the phenophase of fruit formation and ripening, therefore manual and mechanical works to control them would lead to the quantitative and qualitative devaluation of the fruits. Mechanical weed control and weeding after harvest and haying of the foliage, which is practiced in perennial crops, is also difficult, because the speed of growth of weeds is high, the bushes being quickly covered by them. That is why the fight against weeds in strawberries must be carried out permanently and with all means: mechanical, manual and chemical in order to obtain high yields and of very good quality.

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