[1.] Vasilica ŞTEFAN, [1.] Lucreția POPA, [1.] Eugen MARIN, [1.] Ioan-Ciprian MIRON, [1.] Ana-Maria CONSTANTIN

RESEARCH FOR THE DEVELOPMENT OF SOME INNOVATIVE TECHNOLOGIES FOR CONTROL WEEDS IN THE ECOLOGICAL SYSTEM

[1.] INMA Bucharest, ROMANIA

Abstract: One of the known problems with monocultures is that the diversity, abundance, and activity of natural enemies of pests is drastically reduced due to the removal of vegetation that provides critical food resources and overstocking sites necessary for the longevity, reproduction, and survival of many predators and parasites. Economically, in viticulture, the burdens include the need to supply crops with costly external factors of production, such as insecticides, as vineyards lacking functional biodiversity lack the capacity to sponsor their own pest regulation. In this article, innovative methods of combating weeds in the ecological system will be presented.
Keywords: viticulture, cover crop, biodiversity, abrasive weeding

1. INTRODUCTION

Many scientists are concerned that as vineyards expand, the natural vegetation that acts as a refuge decreases, and therefore the contribution to pest suppression by biocontrol agents using these habitats diminishes.

One of the main ecological options for rectifying this habitat is to increase the vegetation diversity of the vineyards and the surrounding landscapes. Plant biodiversity is crucial to crop defense: the more plants and associated animals and soil-borne organisms that inhabit a viticultural system, the more the community of beneficial pest-fighting organisms (predators, parasitoids, and entomopathogens) can support the farm.

Biodiversity in vineyards includes vines, cover crops, weeds, arthropods, soil fauna and microorganisms. The new ecological approach to viticulture with an emphasis on the production of ecologically sound grapes (Vitis vinifera) views the grapevine as part of a complex agroecosystem in which many organisms coexist and interact. In particular, this approach recognizes the importance of interactions between microbial and plant communities (*Likar et al., 2015; Regvar et al., 2012*) as they influence grapevine growth, physiology and yield. The intensification of soil degradation processes and the reduction of water reserves, the multiplication of weeds and pests, make it necessary to use less used methods, such as cover crops. According to research, plant species cultivated in this way reduce erosion and improve soil condition, contribute to water infiltration, reduce the degree of infestation with weeds, diseases, pests and increase biodiversity. *Cover crop* sensures the supply of nutrients from deeper layers at the level of the roots of the crop plant to be cultivated.The components of vineyard biodiversity can be classified in relation to the role they play in the functioning of viticultural systems.

Biodiversity of vineyards can be grouped as follows:

- *Productive biota*: vines and other crops or animals chosen by farmers
- *Functional biota*: organisms that contribute to productivity through pollination, biological control (pest predation and parasitism), decomposition of organic matter, mineralization of nutrients etc.
- *Destructive biota*: weeds, insect pests, microbial pathogens, etc., which farmers aim to reduce through cultural management.

The above biodiversity categories can further be recognized as two distinct components. The first component, planned biodiversity, includes vines and other crops or animals intentionally included in the vineyard by the farmer. The second component, associated biodiversity, includes all soil flora and fauna, herbivores, predators, parasites, decomposers, that live in the vineyard or that colonize from the surrounding environments and that thrive in the system depending on its management (use of chemicals or organic inputs, etc.) and the vegetation diversity of the system.

A major ecological service provided by vineyard biodiversity is the regulation of the abundance of unwanted organisms through predation and parasitism.

Every insect herbivore is attacked to some extent by one or more natural enemies (also called beneficial insects), thus predators, parasites and pathogens act as natural control agents leading to the regulation of the number of herbivores in a given ecosystem. Research has shown that by adding plant diversity to

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

monocultures, it is possible to create habitat conditions that favor natural enemy abundance and effectiveness. In diverse plant cropping systems, there is generally an increased abundance of arthropod predators and parasitoids due to increased availability of alternative prey, nectar sources, and suitable shelter.

Habitat management is based on the idea that one of the most powerful and long-lasting ways to minimize economic damage caused by pests is to boost naturally existing populations of beneficial organisms by providing them with suitable habitats and alternative food sources Most vineyards are inhabited by a variety of natural enemies, but their abundance will depend on the growers' use of toxic pesticides and maintaining a reasonable amount of plant diversity in the vineyard.

For organic farms that do not rely on the use of synthetic fertilizers, one reason to grow cover crops is to increase the amount of nitrogen in the soil. In this sense, leguminous crops can provide a substantial amount of nitrogen. In viticulture, however, most of them use mixtures of phacelia, buckwheat and peas. According to *Guerra and Steenwerth*, cover crops can improve soil and vine health and influence vine vigor by adjusting parameters such as canopy efficiency and shoot growth period (*Guerra, B.; Steenwerth, K., 2012*). A major ecological service provided by vineyard biodiversity is the regulation of the abundance of unwanted organisms through predation and parasitism.

Biological control can be self-sustaining and is distinguished from all other forms of pest control by acting in density and/or in a density-dependent manner, ie: natural enemies increase in intensity and destroy a larger population of the population as the population density it increases vice versa. The goal of biological control is to keep a target pest below economically harmful levels—not to eliminate it completely—because population decimation also removes a critical food resource for natural enemies that depend on it.

Among the many benefits of cover crops (protecting soils against erosion, improving soil fertility, improving soil structure and water-holding capacity) is the provision of habitat for predators and parasitic arthropods. A variety of weed-control methods can be used, including crop rotation, cover crops, natural substances (such as corn gluten meal), etc. In some cases, stand-alone methods and even integrated tactics have led to inadequate weed control and crop production reduction. *(Johnson et al. 2013).*

Some alternative solutions are unaffordable due to the high application rates of some products or labor requirements for efficient weed management (*Boyd and Brennan, 2006*).

2. MATERIALS AND METHODS

During year 2021, in the framework of the ADER 7.5.7 project, the partners involved in the project carried out actions to combat weeds and pests, but also to control diseases in the ecological experimental lots, namely:

≡ phytosanitary treatments;
≡ planting rows of vines;
≡ sandblasting the weeds.

INMA Bucharest applied an innovative method of weed control, namely the sandblasting method.

Weed blasting is a new weed control technology that has the potential to reduce the amount of agricultural work in organic farming. The technology offers the possibility of using technical equipment that can apply organic fertilizers as abrasives to fight weeds and supplement crop nutrition in a single pass.

During year 2021, the innovative technology of ecological weed control by the sandblasting method (abrasive weeding) was tested. The activities carried out for this purpose were the following:

≡ Preparation for testing the technical equipment intended for the innovative technology of ecological weed control by the sandblasting method (abrasive weeding);
≡ Experimentation in field conditions of the weed blasting equipment intended for the innovative technology of ecological weed control by the sandblasting method (abrasive weeding).

In order to carry out the research on the experimental grape plots of the Murfatlar Research and Development Station for Viticulture and Winemaking which are substantially larger than the weeds that emerged at the time of application, the weed blasting equipment used in order to continue the testing was subjected to research experimental in laboratory and field conditions to optimize the sandblasting process. The testing of the sandblasting method involved the use of two types of abrasive grains, namely:

≡ soybean flour obtained by grinding yellow soybeans;
≡ sand for sandblasting with a grain size of 0.4-0.8 mm.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

While working with the weed blasting equipment equipped with two lamellar jet nozzles, it was found that the blasting sand was directed to the ground in an amount that could not be adjusted, due to the fact that the technical equipment is not provided with adjustment accurate flow rate of injected abrasive material.

Under these conditions, for the uniform distribution of pressure and the air-organic material mixture, theoretical research was carried out for the realization of Venturi nozzles with three sizes of the outlet opening, which would have an extended footprint of the sandblasting jet and an increased speed of the abrasive by up to 100% at a given pressure.

To simulate their operation in laboratory conditions, the SOLIDWORKS® Flow Simulation module was used, which is an intuitive Fluid Dynamics (CFD) solution incorporated in SOLIDWORKS 3D CAD (*Marin e et al., Gheorghe G., Băltatu C., Mateescu M., 2022*)

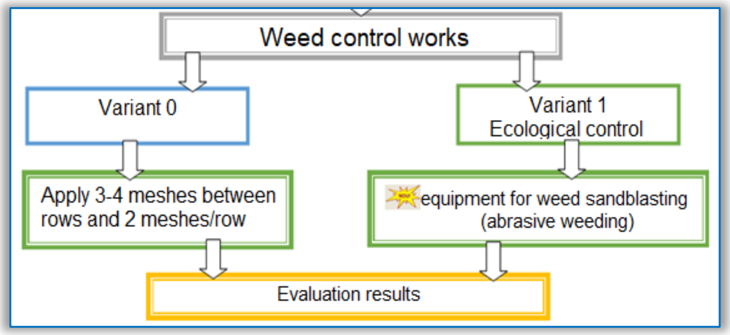

Figure 1 - Innovative technology for ecological weed control by the sandblasting method (abrasive weeding)

For the physical realization of the nozzles, the UP BOX type 3D printer dedicated to use in the office environment was used, with which exceptional quality parts were obtained. The heated platform and closed enclosure provided a minimization of the risk of nozzle deformation.

The innovative technology to control weeds by the sandblasting method is presented below:

The technology involves blasting young weeds with small fragments of organic material, using an air compressor.

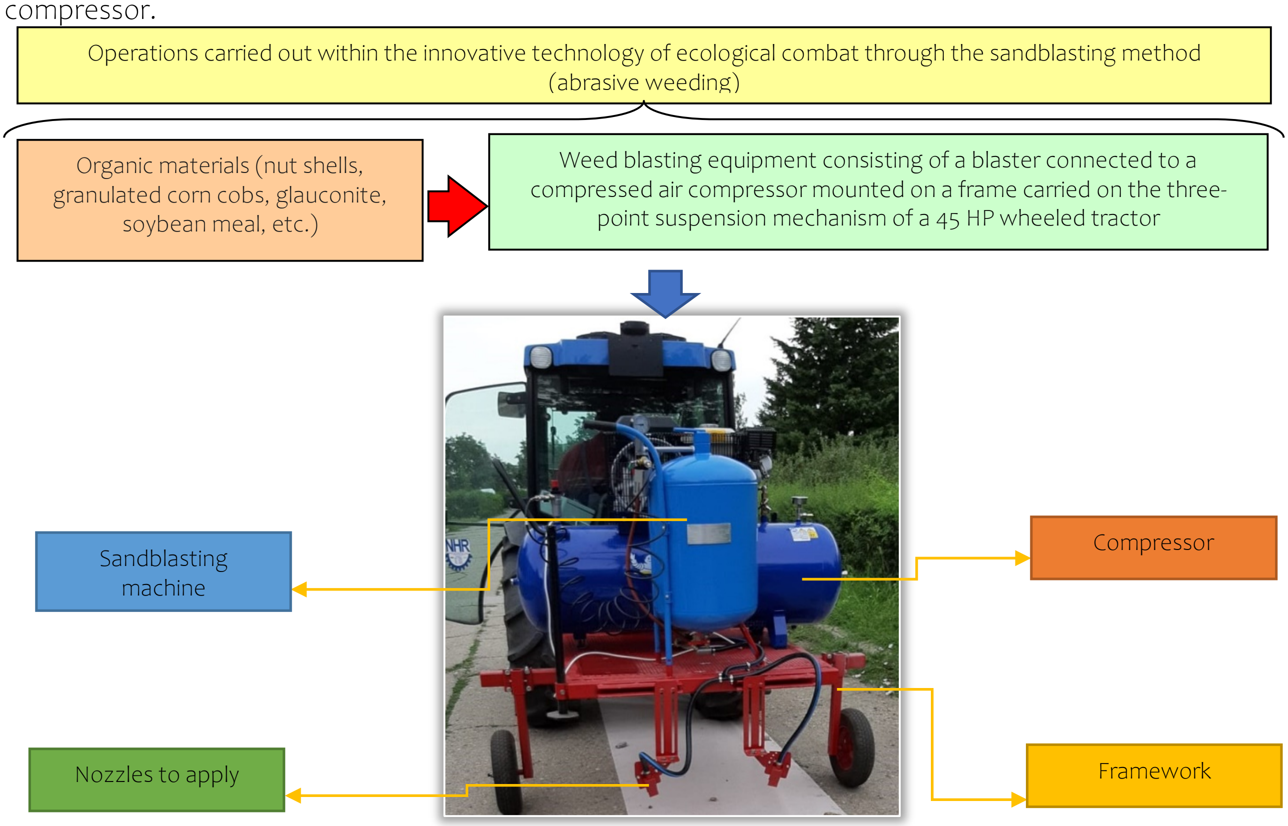

Figure 2 - Operations carried out within the innovative technology of ecological combat by the sandblasting method (abrasive weeding)

Organic materials (nut shells, granulated corn cobs, glauconite, soybean meal, etc.) were applied using a weed blasting equipment consisting of a blasting machine connected to a compressed air compressor mounted on a carried frame on the three-point suspension mechanism of a 45 HP wheeled tractor. If applied during the weed growth phase, the abrasive "sand" deeply destroys both the stem and the leaves of the weed, because when it leaves the nozzle, it has a speed of at least Mach 1, i.e. over 1,230 kilometers per hour.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

The substance comes out so quickly that it doesn't really matter what the shape of the particle is.

The material is directed to two nozzles, each nozzle directed to one side of the plant row over a width of 70 to 100 mm.

Granule particles reach the tip of each nozzle by being entrained by the air jet under a pressure of around 8 bar and are directed at high speeds towards the small weeds near the base of the plants

The following figure shows Venturi nozzles, which have been physically executed with three different sizes of the outlet diameter of the sandblasting material, so that an extended footprint of the sandblasting jet and an increased abrasive velocity of up to 100%, at a given pressure, in order to evenly distribute the pressure and air-organic material mixture that will be used in weed blasting.

The nozzles, which were made by 3D printing, are characterized by the flow geometry that produces a compact beam, controlled by the parabolic distribution of the sandblasting jet and insensitive to pressure fluctuations. The created nozzles were mounted on an industrial sandblasting gun with which the technical sandblasting equipment was equipped in order to dose depending on the size of the discharge diameter of the sandblasting material.

During the tests, determinations were made regarding the distance between rows of vines, the distance between plants and their height.

Figure 3 - Venturi nozzles

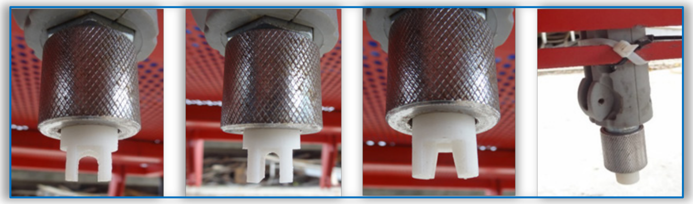

Figure 4 - Installation of nozzles with the three sizes of the diameter of discharge on the sandblasting gun

Distance between rows	Distance between plants	Plant height
2 m	1.1 m	1.9 m

Figure 5 - Aspects during measurements

Calibrated weed blasting equipment is tested in the vineyard at SCDVV Murfatlar, this one it is also equipped with a sandblasting gun-injector, and the dosage was made according to the size of the sandblasting nozzle, which had the final result of obtaining a higher efficiency of the sandblasting process and at the same time the possibility of precise adjustment of the flow of abrasive material injected.

Figure 6 - Sandblasting equipment in operation

Figure 7 - Manual spraying of the blasting material

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

Figure 8 - Appearance of weeds after blasting (leaf damage)

Figure 9 - Appearance of the plant before and after blasting

The results of testing the sandblasting method compared to the cultivated field are presented in the table below. They were carried out in March 2021 and consisted of:

≡ spring plowing and obtaining the black field in which 90% of the weeds between the vine rows and 30% of the weeds between the plants (per row) were destroyed
≡ sandblasting with abrasive materials both between rows (automatic sandblasting equipment) and between plants (manual sandblasting equipment).

Table 1. The vine varieties where the tests were performed are: Columna and Black Maiden *(Feteasca neagra)*

No. crt.	Weed species	COLUMN		Black Maiden	
		Degree of infestation %		Degree of infestation %	
		Cultivated field	The innovative method - sandblasting	Cultivated field	The innovative method - sandblasting
	monocotyledonous				
1	*Agropyron repens*	88	65	80	68
2	*Cynodon dactylon*	84	74	75	70
3	*Perennial Lolium*	76	65	74	61
4	*Poa angustifolia*	84	71	89	79
5	*Dactylis glomerata*	62	80	87	77
6	*Setaria viridis*	74	72	65	74
7	*Echinochloa crus-galli*	65	61	76	63
	dicotyledonous				
1	*Convolvulus arvensis*	88	80	89	74
2	*Cirsium arvense*	76	74	74	68
3	*Sonchus arvensis*	69	76	78	62
4	*Dear Cardaria*	78	81	69	63
5	*Taraxacum officinale*	86	77	87	65
6	*Trifolium repens*	76	70	88	74
7	*Trifolium pretense*	88	75	92	77
8	*Plantago major*	79	74	77	76
9	*Achillea millefolium*	77	73	85	77
10	*Veronica chamaedrys*	89	76	84	79
11	*Amaranthus retroflexus*	84	77	71	62
12	*Chenopodium album*	88	80	76	73
13	*Stellaria media*	78	63	69	62
14	*Solanum*nigrum	77	76	70	66
15	*Polygonum aviculare*	89	71	68	62
16	*Senecio vulgaris*	88	70	78	66
17	*Tatar Atriplex*	64	73	81	63

The environmentally friendly technology of weed control by sandblasting can reduce the final biomass of weeds by 60-80% compared to weed control where the degree of destruction varies between 62-92%, regardless of the type of granulation or the frequency of application.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

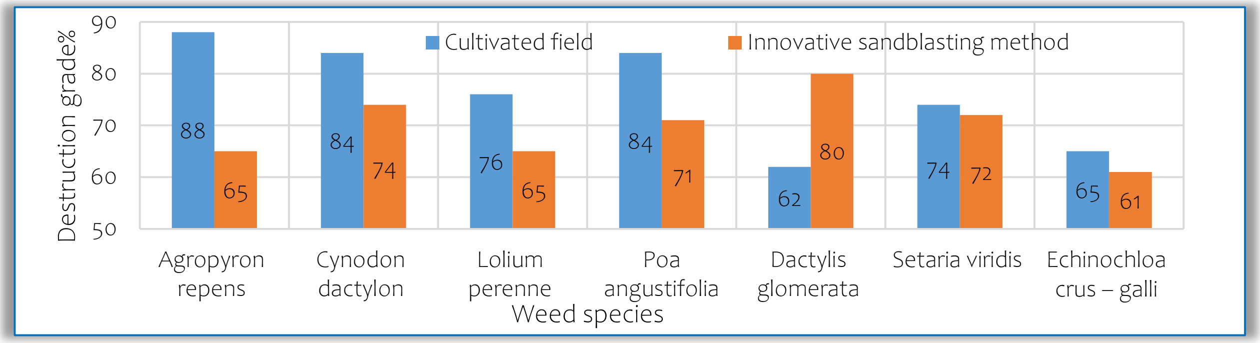

Figure 10 - Control of monocotyledonous weeds in the Columna variety

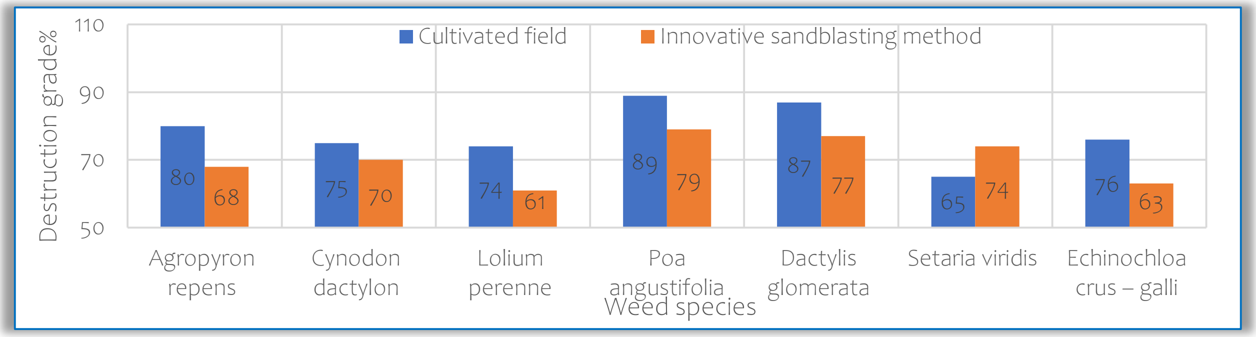

Figure 11 - Control of monocotyledonous weeds in the variety Black Maiden

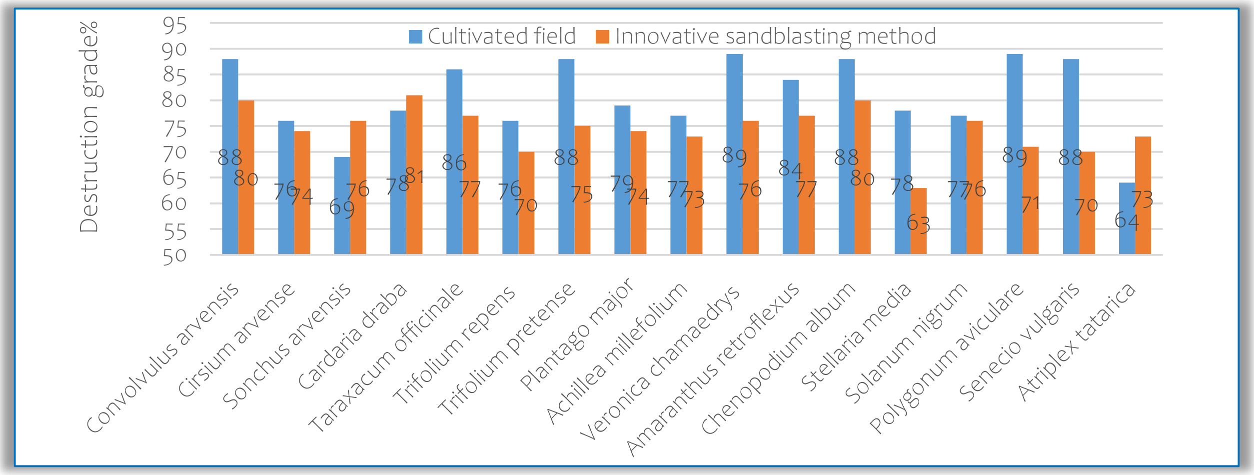

Figure 12 - Control of dicotyledonous weeds in the Columna variety

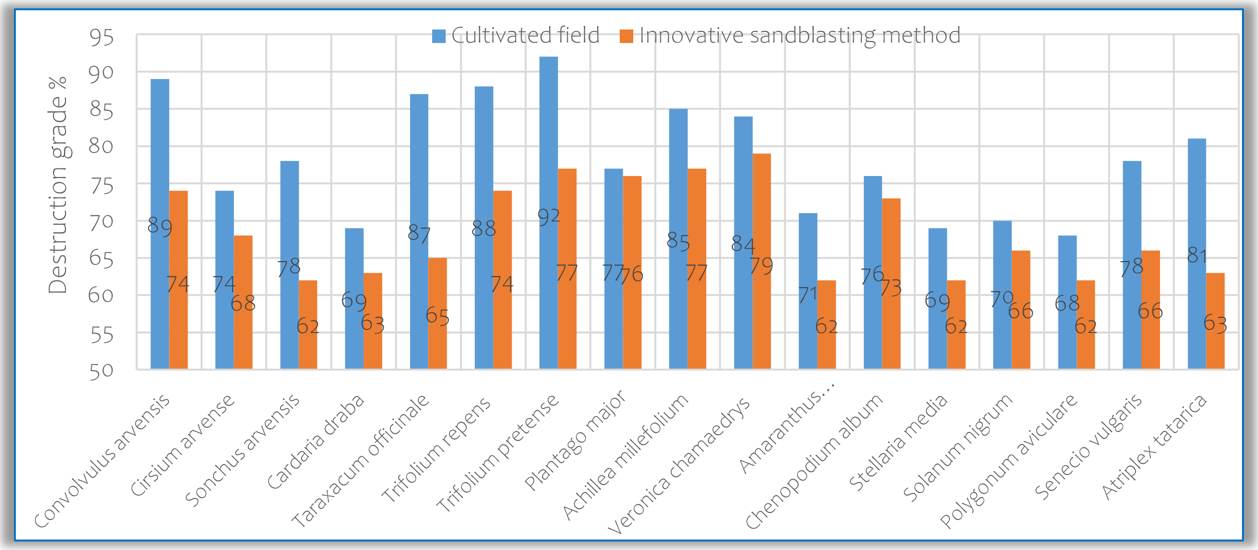

Figure 13 - Control of dicotyledonous weeds in the variety Black Maiden

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN-L 1584 – 2665

3. CONCLUSIONS

An additional advantage of weed blasting relates to the potential for growers to use organic fertilizers, such as soybean meal, as blasting material.

The costs of applied abrasives, based on market prices (where available), are acceptable to organic farmers, especially compared to manual threshing. Examining a greater number of weed species and types of abrasive materials and understanding their properties (such as surface roughness and density) that promote better control will allow greater understanding of how best to improve this new weed control technologies.

Considering the data obtained, it can be stated that the sandblasting method is a viable option for the ecological destruction of weeds, being useful both from the point of view of combating them but also as a potential organic fertilizer for the plantation.

Note: This paper was presented at ISB–INMA TEH' 2022 – International Symposium on Technologies and Technical Systems in Agriculture, Food Industry and Environment, organized by University "POLITEHNICA" of Bucuresti, Faculty of Biotechnical Systems Engineering, National Institute for Research–Development of Machines and Installations designed for Agriculture and Food Industry (INMA Bucuresti), National Research & Development Institute for Food Bioresources (IBA Bucuresti), University of Agronomic Sciences and Veterinary Medicine of Bucuresti (UASVMB), Research–Development Institute for Plant Protection – (ICDPP Bucuresti), Research and Development Institute for Processing and Marketing of the Horticultural Products (HORTING), Hydraulics and Pneumatics Research Institute (INOE 2000 IHP) and Romanian Agricultural Mechanical Engineers Society (SIMAR), in Bucuresti, ROMANIA, in 6–7 October, 2022.

References

[1] Boyd, NS and Brennan, EB 2006. Burning nettle, common purslane, and rye response to clove oil herbicide. Weed Technology, Vol.20, pp. 646–650;
[2] Guerra, B.; Steenwerth, K. (2012). Influence of floor management technique on grapevine growth, disease pressure, and juice and wine composition: A review. J. Enol. Vitic. 63, pp. 149–164;
[3] Johnson, WC III, Boudreau, MA, and Davis, JW. (2013). Combinations of corn gluten meal, clove oils and sweep cultivation are ineffective for weed control in organic peanut production. Weed Technology, vol. 27, pp. 417–421.
[4] Likar, K. Vogel-Mikuš, M. Potisek, K. Hančević, T. Radić, M. Nečemer, M. Regvar, (2015). Importance of soil and vineyard management in the determination of grapevine mineral composition. Science of The Total Environment, Volume 505, pp. 724-731;
[5] Marin E., Gheorghe G., Bălţatu C., Mateescu M., (2022), Application of 3d printing technology for the design and manufacture of some component parts of spraying machine with solution recovery. INMATEH–Agricultural Engineering, Vol. 67, pp. 147-154, Bucharest/Romania.;
[6] Regvar, Marjana Likar, Matevž & Katarina, Hančević & Tomislav, Radic (2012). Distribution and diversity of arbuscular mycorrhizal fungi in grapevines from production vineyards along the eastern Adriatic coast. Mycorrhiza.

ISSN 1584 – 2665 (printed version); ISSN 2601 – 2332 (online); ISSN–L 1584 – 2665