International Journal of Biological, Life and Agricultural Sciences
ISSN: 2415-6612
Vol:10, No:4, 2016

Effect of Biostimulants to Control the *Phelipanche ramosa* L. Pomel in Processing Tomato Crop

G. Disciglio, G. Gatta, F. Lops, A. Libutti, A. Tarantino, E. Tarantino

Abstract**—**The experimental trial was carried out in open field at Foggia district (Apulia Region, Southern Italy), during the spring-summer season 2014, in order to evaluate the effect of four biostimulant products (Radicon®, Viormon plus®, Lysodin® and Siapton® 10L), compared with a control (no biostimulant), on the infestation of processing tomato crop (cv Dres) by the chlorophyll-lacking root parasite *Phelipanche ramosa*. Biostimulants consist in different categories of products (microbial inoculants, humic and fulvic acids, hydrolyzed proteins and aminoacids, seaweed extracts) which play various roles in plant growing, including the improvement of crop resistance and quali-quantitative characteristics of yield. The experimental trial was arranged according to a complete randomized block design with five treatments, each of one replicated three times. The processing tomato seedlings were transplanted on 5 May 2014. Throughout the crop cycle, *P. ramosa* infestation was assessed according to the number of emerged shoots (branched plants) counted in each plot, at 66, 78 and 92 day after transplanting. The tomato fruits were harvested at full-stage of maturity on 8 August 2014. From each plot, the marketable yield was measured and the quali-quantitative yield parameters (mean weight, dry matter content, colour coordinate, colour index and soluble solids content of the fruits) were determined. The whole dataset was tested according to the basic assumptions for the analysis of variance (ANOVA) and the differences between the means were determined using Tukey's tests at the 5% probability level. The results of the study showed that none of the applied biostimulants provided a whole control of *Phelipanche*, although some positive effects were obtained from their application. To this respect, the Radicon® appeared to be the most effective in reducing the infestation of this root-parasite in tomato crop. This treatment also gave the higher tomato yield.

Keywords**—**Biostimulants, control methods, *Phelipanche ramosa*, processing tomato crop.

I. Introduction

PHELIPANCHE ramosa L. Pomel, also known *as Orobanche ramosa* L., is a chlorophyll-lacking root parasite of many Dicotyledonous species, which cause severe damage to vegetable field crops, and particularly to processing tomato crop, in Apulia region (Southern Italy).

The main difficulties in controlling this parasitic weed arise from the distinctive properties of the seed, such as the very high number, minute size, extreme longevity and ease dispersal. These aspects cause a rapid increase in the parasite soil seed banks, even when the original infestation area is very limited. Containment of infested areas and prevention of seed distribution should therefore be the main objectives of these parasitic weed management strategies, in addition to direct control interventions [1].

Obviously, all means to limit the development of *P. ramosa* in agricultural field may not only reduce the direct damage to the crop, but also limit the production of additional seeds, which replenish the local seedbank and at the same time increase the risk that non-infested areas will also be contaminated. Various approaches are possible for seedbank reduction, including soil fumigation and solarization, application of suicidal germination agents, catch and trap crops cultivation, management of soil tillage (minimum tillage and deep-plowing), adoption of chemical and biological control methods [2]-[6]. In addition, high availability of nutrients in the soil usually promotes less development of the radical system, decreasing the likelihood of root recognition by parasitic seeds [7], [8]. Indeed, it has long been recognized that *P. ramosa* is most problematic on soils with low fertility [9]. An explanation of this phenomenon is the increase in the release of germination stimulants from roots that suffer from nutritional deficiencies [10]. As indicated above, availability of soil nutrients can influence parasitic plant development in several ways [11]. Some compounds of natural origin, such as natural aminoacids were also suggested for use in *P. ramosa* management strategies, being able to inhibit seed germination or seedling elongation or, conversely, stimulate suicidal seed germination in the absence of the host [12], [13]. In recent years, the use of organic fertilizers or biostimulant compounds has encountered increasing interest in agriculture because they play roles in various soil and plant functions, such as the improvement of crop resistance to stresses, the control of nutrient availability in the soil and the enhancement of quali-quantitative aspects of crop yield [14], [15]. Biostimulants consist in different categories of products: microbial inoculants, humic and fulvic acids, hydrolyzed proteins and aminoacids, seaweed extracts [16]. Considering the very few researches carried on the use of biostimulants to control the *Phelipanche* [17], [18], this paper deals with the results of some natural biostimulants application to an open field processing tomato crop for the control of this parasitic infestation.

II. Materials and Methods

The study was carried out during the spring-summer season 2014, at the private "Pazienza" farm, located in an agricultural area of the Foggia district (Apulia Region, Southern Italy, 41°27'N; 15°31'56"E), where the cultivation of processing tomato crop (*Lycopericon esculentum* Mill.) is very intensive and the infestation of *Phelipanche ramosa* is widely diffuse.

Disciglio G., Gatta G., Lops F., Libutti A., Tarantino A., Tarantino E. are with the Department of Agricultural, Food and Environmental Science, University of Foggia - 71122 Foggia, Italy (phone: +39 0881589309; e-mail: annalisa.tarantino@unifg.it).

The trial was carried out with the processing tomato cultivar "Dres" which produces elongated-fruits for peeled fruits. Four biostimulant treatments, respectively corresponding to the application of four biostimulant products (Radicon®, Viormon plus®, Lysodin® and Siapton® 10L) to the plants, were considered. The four treatments were compared with an untreated control. The aim was to assess the effect of biostimulants on the control of *P. ramosa* infestation

In Table I, the composition, time and mode of application of the commercial products used in the experiment are reported.

TABLE I
COMPOSITION, TIME AND APPLICATION MODE OF THE BIOSTIMULANT PRODUCTS USED IN THE EXPERIMENT

BIOSTIMULANT PRODUCT
RADICON® (Fertek) A suspension–solution containing humic and fulvic acids, obtained from compost of worm (night crawled). It was applied at transplanting, by soaking the tomato seedling roots, at 1.5%concentrated solution.
VIORMON PLUS® (Farma – Chem Sa) A solution of nicotinic acid (0.1%), vitamin B1 (0.1%) and boron (2%). It was applied by foliar treatment, at dose of 50 ml L^{-1} of water, at 30 and 52 day after transplanting (DAT).
LYSODIN ALGA-FERT® (Intrachem Bio Italia Spa). A solution of boron, ethanolamine (2%), vitamin B1 (0.1%) and vitamin B3 (0.1%). It was applied by foliar treatment, at the dose of 50 ml L^{-1} of water at 30 and 52 DAT.
SIAPTON 10 L® (Siapa). A formulation based on aminoacids and peptides obtained by chemical hydrolysis of animal epithelium. It was applied by foliar treatment, at the dose of 300 mL 100 $^{-1}$ L of water, at 30 and 52 DAT.

The experiment trial was arranged according to a complete randomized block design with each of the abovementioned treatments replicated three times. The trial was carried out on a medium texture soil (USDA classification), whose main physico-chemical characteristics are given in Table II.

TABLE II
MAIN PHYSICAL-CHEMICAL SOIL CHARACTERISTICS

Sand [2.0> Ø < 0.02 mm]	(%)	47.20
Loam [0.02 > Ø < 0.002 mm]	(%)	32.39
Clay [Ø < 0.002 mm]	(%)	20.40
Tipology (USDA)	Medium-texured	
Organic matter (Walkley-Black)	(%)	2.3
pH (in H_2O)		8.4
Electrical Conductivity on soil satured extract (ECe)	(dS cm^{-1})	0.3
NO_3-N	(mg kg)	4.88
NH_4-N	(mg kg)	4.13
Total nitrogen (Kjeldhal)	(‰)	1.1
P_2O_5 available (Olsen)	(mg kg)	65.0
K_2O exchangeable (Shollemberger)	(mg kg)	130

The processing tomato seedlings were transplanted into plots of 10 m^2 on 5 May 2014, in double rows (40 cm apart) spaced at 200 cm, with the plants at the distance of 30 cm along each single row, resulting in a theoretical plant density of 3.3 plants m^{-2}.

A drip irrigation method was used with the drip lines placed between each couple of plant rows. The water volume at each irrigation varied from 100 m^3 ha^{-1} to 300 m^3 ha^{-1}, depending on the crop growth stage, with a watering interval of about 3-4 days. The agricultural management practices applied to tomato crop during the experimental trial were those commonly adopted by local farmers, such as for fertilizing and for weed and pest control.

During the tomato cycle, at 66, 78 and 92 days after transplanting (DAT), *Phelipanche* emerged shoots (branched plants) from soil on a sampling area of 1 m^2 were counted.

The tomato fruits were harvested at full-stage of maturity on 8 August 2014, when the marketable yield from each sampling area of 5 m^2 was measured. On a sample of 10 fruits from each plot, the following main quali-quantitative yield parameters were determined: mean weight (g), soluble solids content (°Brix) and dry matter content (% fruit fresh matter) [19]. The colour index [20] and the L coordinate [21] were measured using a spectrophometer (CM-700d; Minolta Camera Co. Ltd.), on four randomly selected areas of the fruit surface.

All data were subjected to analysis of variance (ANOVA) and the means were compared by Tukey's test.

III. RESULTS AND DISCUSSION

A. Climate Conditions of the Experimental Site

The 10-day (decade) mean climate parameters recorded during the 2014 growing season are reported in Fig. 1. The mean temperature increased almost linearly through the summer, from 15.1°C on 1 May, to 24.2°C on 1 August. Through the season, the total evaporation varied from 35 mm to 60 mm, while the total rainfall was only high in the second decade of June, with 50 mm recorded.

B. Effects of Treatments on the Control of Phelipanche ramosa

As shown in Fig. 2, *P. ramosa* shoots were detected during the growing tomato crop at 66, 78 and 92 days after transplanting (DAT), for all of the tested treatments. The number of *Phelipanche* emerged shoots from 1 m^2 of soil surface, altough with differences among treatments, increased particularly between 66 and 78 DAT. In particular, no significant differences among the treatments at 66 DAT were observed, while significant differences were recorded at 78 and 92 DAT, when the Radicon® treatment showed significantly lower values than the other treatments.

Similar results were observed in previous studies [17], [18]. At the end of the tomato crop cycle (92 DAT), the mean numbers of *P. ramosa* emerged shoots varied from 19.0 to 38.0 per m^2, according to the treatment. In comparison with the untreated control, reductions of 50%, 71%, 74% and 66% of *P. ramosa* emerged shoots were respectively recorded for Radicon®, Viormon plus®, Lysodin® and Siapton® 10L treatments.

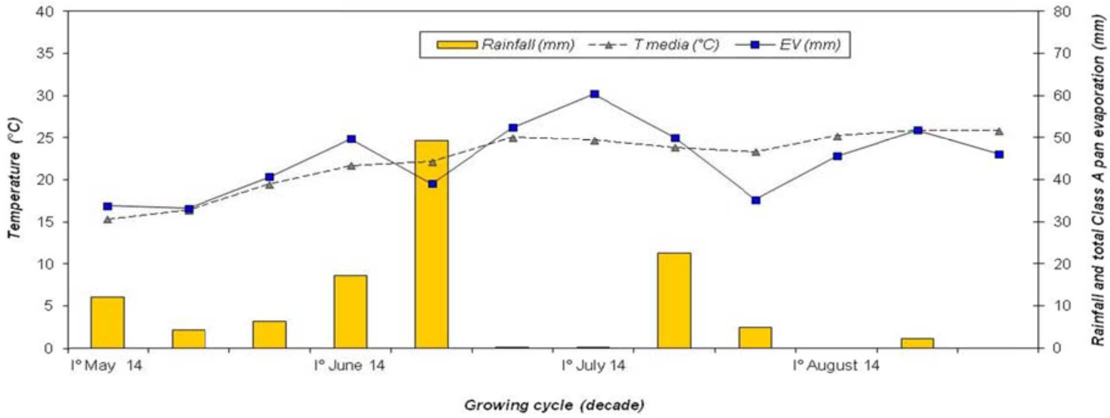

Fig. 1 Mean temperature (T), total 10-day (decade) rainfall, and class A pan evaporation (EV) during the tomato-growing season

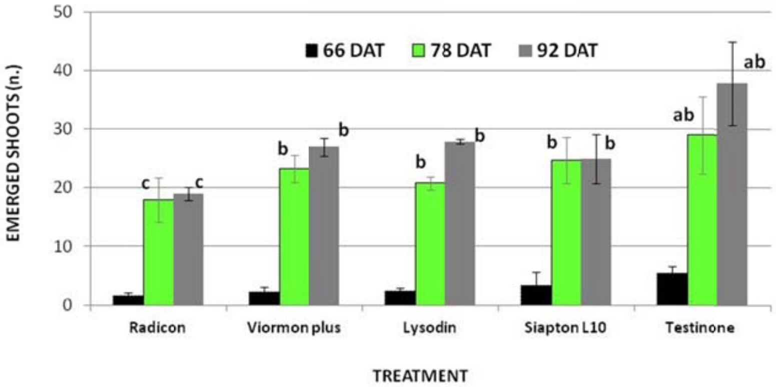

Fig. 2 Number of emerged shoots of *P. ramosa* at 66, 78 and 92 day after transplanting (DAT) for the different biostimulant treatments: Data are means ± standard error, as measured from each plot of each treatment. Means with different letters are significantly different at P ≤ 0.05 (Tukey's test)

C Effects on Quali-Quantitative Parameters

Table III gives the effects of the different experimental treatments on the quali-quantitative traits of the processing tomato fruits.

Except for Siapton® L10, the marketable yield of the biostimulant treatments was higher than the untreated control. The highest yield was observed in the Radicon® treatment, although it was not significantly different from the Viormon plus® and Lysodin® treatments. This result is in agreement with the lower parasite attach observed in tomato plants treated with Radicon®. The higher marketable yields appear to be mainly due to the high mean weight of fruits. Also the dry matter percentage was significantly higher in the Radicon® treatment than the others treatments, while regarding the other fruit characteristics, such as the colour coordinate, colour index and the soluble solids content, no significant differences were observed.

TABLE III
QUANTI-QUALITATIVE TRAITS OF THE TOMATO FRUIT UNDER THE DIFFERENT TREATMENTS

Parameter	Radicon®	Viormon plus®	Lysodin®	Siapton® L 10	Control	Significance
Marketable yield (t ha^{-1}) †	106.5±11,32a	101.67±4.91ab	101.50±9.75ab	83.67±4.33b	93.00±3.91b	*
Mean fruit weight (g)	78.67±4.41a	72.67±3.33ab	68.33±4.41ab	73.67±4.41ab	74.67±4.41ab	*
Dry matter (% fresh matter)	6.64±0.53a	5.74±0.35b	5.75±0.62b	6.22±0.16b	5.45±0.64b	*
Colour coordinate (L)	40.83±0.55	40,70±1.62	40.43±1.03	38.94±0.25	40.48±0.18	n.s.
Colour index (a/b ratio)	1.07±0.04	1.04±0.03	1.08±0.01	1.07±0.05	1.09±0.05	n.s.
Soluble solids content (°Brix)	3.9±0.47	4.1±0.03	4.2±0.40	4.20±0.12	4.3±0.24	n.s.

† Marketable yield data are means±standard error, as measured from sampling area of 15 m^2

Other data (Mean fruit weight, Colour coordinate, Colour index, Soluble solids content and Dry matter) are means ±standard error, as measured from 30 marketable fruits (10 fruits per plot × 3 replicates). Means followed by the same letters in each row are not significantly different (P=0.05, Tukey's tests); ns, F test not significant; * F test significant at P <0.05.

IV. Conclusions

Agronomic strategies that reduce the *Pheliphanche* weed seed bank, in one way or another, include nitrogen and sulphus fertilizer, phytosanitary measures, hand weeding, soil solarization, crop rotations or intercropping with catch and trap crops. These measures by themselves are not sufficiently effective to completely eliminate the seed bank of parasitic weeds but can impede or reduce seed production and dispersal.

In view of the importance of processing tomato as major cash crop for farmer and the heavy losses in the field mainly due to this harmful weed in Apulia region (southern Italy), very important is to integrate the above methods with direct additional one. Biostimulants are known as the organic materials which promote plant growth and help plants to withstand hashed environments when applied in small quantities. This trial aims to study the response of tomato Dres cultivar to foliar or soil applications of four biostimulants products (Radicon®, Viormon plus®, Lysodin® and Siapton® 10L).

The main conclusion to be drawn from this study is that the use of biostimulants no provides complete control of *Phelipanche,* although the soil application of Radicon® biostimulant is particularly suitable to produce lower presence of this parasite. It is assumed that these effects can be improved by combining these treatments with agronomic methods approaches especially for a gradual and continuing reduction of the "seed bank" of the parasite in the soil.

Therefore, more investigation should be carried out with integrated methods for the control of this parasitic in processing tomato crops.

Acknowledgment

This work was carried out within the project "OROPOMVEG" approved by the Apulia region within the "Linee Guida, 2012-2014" for the research and experimentation in agriculture.

References

[1] D. Rubiales, M. Fernandez-Aparicio, K. Wegmann, D.M. Joel, 2009. Revisiting strategies for reducing the seed bank of *Orobanche* and Phelipanche spp.. *Weed Res.*, 49, 23-33.

[2] D.K. Berner DK, R. Carsky, K. Dashiell, J. Kling, V. Manyoung, 1996. A land management based approach to integrated *Striga hermonthica* control, in sub-Saharan Africa. *Outlook on Agriculture,* 25, 157-164.

[3] C.M. Ghersa, M.A. Martinez- Ghersa, 2000. Ecological of weed seed size and persistence in the soil under different tilling system; implications for weed management. *Field Crops Research* 67, 141-148.

[4] Z.Y. Ashrafi, M.A. Hassan, H.R. Mashhadi; S. Sadeghi, 2009. Applied of soil solarization for control of Egyptian broomrape (*Orobanche aegyptiaca*) on the cucumber (*Cucumis sativus*) in two growing seasons. *J. Agril. Technol.,* 5(1), 201-212.

[5] A. Habimana, J.D. Nduwumuremyi, R. Chinama, 2014. Management of *Orobanche* in field crops- A review. *Journal of Soil Science and Plant Nutrition,* 14(19), 43-62.

[6] G. Disciglio, F. Lops, A. Carlucci, G. Gatta, A. Tarantino, L. Frabboni, F. Carriero, F. Cibelli, M. L. Raimondo, E. Tarantino, 2015a. *Phelipanche ramosa* (L. - Pomel) Control in Field Tomato Crop. *World Academy of Science, Engineering and Technology International Journal of Agricultural, Biosystems Science and Engineering.* Vol. 9 No 1, 13-17.

[7] B.E. Abu-Irmaileh 1994. Nitrogen reduces branched broom-rape *(Orobanche ramosa)* seed germination. *Weed Science* 42, 57-60.

[8] M.O. Ahonsi, D.K Berner, A.M Emechebe, S.T. Lagoke, N. Sangina, 2004. Effects of ALS - inhibitor herbicides, crop sequence, and fertilization on natural soil supressiveness to *Striga hermonthica. Agriculture, Ecosystems and Environment,* 104, 453-463.

[9] Jain & CL Foy, 1992. Nutrient effects on parasitism and germination of Egyptian broomrape (*Orobanche aegyptiaca). Weed Technology* 6, 269-275.

[10] K. Yoneyana, X. Xie, D. Kusumoto, et al., 2007. Nitrogen deficiency as well as phosphorus deficiency in sorghum promotes the production and exudation of 5-deoxystrigol, the host recognition signal for arbuscular mycorrhizal fungi and root parasites. *Planta* 227, 125-132.

[11] J. Sauerborn, B. Kranz, H. Mercer-Quarshie H., 2003. Organic amendments to mitigate heterotrophic weed population in savannah agricolture. *Applied Soil Ecology* 23, 181-186.

[12] M. Vurro, B. Boari, A.L.,Pilgeram, D.C. Sands, 2005. Exogenous aminoacids inhibit seed germination and tubercle formation by Orobanche ramosa (Brooomrape): potential application for management of parasitic weed. *Biological Control*, 36, 258-265.

[13] M. Vurro, B. Boari, A. Evidente, A. Andolfi, N. Zermane, 2009. Natural metabolites for parasitic weed management. *Pest Management Science*, 65, 566-571.

[14] Biostimulant Coalition, 2013. What are biostimolants? http://www.niostimolantcoalition.org/about/

[15] E. Tarantino, G. Disciglio, L. Frabboni, A. Libutti, G. Gatta, A. Gagliardi, A. Tarantino A., 2015. Effects of biostimulant application on quali-quantitative characteristics of cauliflower, pepper and fennel crops under organic and conventional fertilization. *World Academy of Science, Engineering and Technology International Journal of Agricultural, Biosystems Science and Engineering.* Vol. 9 No 7, 685-689.

[16] Calvo P, Nelson L, Kloepper JW (2014). Agricultural uses of plant biostimulants. *Plant Soil,* 383, 3-41.

[17] G. Disciglio, F. Lops, A. Carlucci, G. Gatta, A. Tarantino, E. Tarantino, 2015b. Effect of different methods to control the parasitic weed *Phelipanche ramosa* (L.- Pomel) in tomato crop. *World Academy of Science, Engineering and Technology International Journal of Agricultural, Biosystems Science and Engineering,* vol. 9, No:4, 371-375.

[18] G. Disciglio, F. Lops, A. Carlucci, G. Gatta, A. Tarantino, L. Frabboni, F. Carriero, E. Tarantino E., 2016. Effects of different methods to control the parasitic weed *Phelipanche ramosa* (L.) Pomel in processing tomato crops. *Italian Journal of Agronomy,* vol. 11:681, 39-46.

[19] AOAC, 1990. Official method of analysis (No 934,06). Association of Official Analytical Chemists (AOAC), Washington, DC, USA.

[20] M. Jiménez-Cuesta, J. Cuquarella, J.M. Martinez-Javaga, 1981. Determination of color index for citrus fruit degreening. Proc. Int. Citricult., 2, 750-3.

[21] F.J. Francis, F.M. Clydesdale, 1975. Food colorimetry: theory and applications. *AVI Publ. Co.,* Westport, CT. pp. 477.