# Effect of Biofumigation on Typical Weeds of Strawberry Fields

Nuria Lopez-Martinez[1], Silvia Castillo[1], Itziar Aguirre[1], Jose E. Gonzalez-Zamora[1], Carlos Avilla[1], and Jose Lopez-Medina[2]

[1]Departmento de Ciencias Agroforestales, Universidad de Sevilla, Ctra. Utrera km 1, 14013-Sevilla, Spain. Email: nlopez@us.es
[2]Departmento de Ciencias Agroforestales, Universidad de Huelva, Huelva, Spain.

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## Abstract

**This research was conducted to evaluate the effect of biofumigation using fresh organic matter on typical weeds present in strawberry fields of southern Spain. Field experiments consisted of biofumigation (BF) treatment over 45 days, at two locations, with hen droppings or horse manure at a dose of 3 kg $m^{-2}$, alone or in combination with solarization (BF+S) in an experimental randomized block design. Results showed good control of the main weed species, *Poa annua, Portulaca oleracea* and *Lolium rigidum*, with comparative populations of the three species under BF/BF+S of 42/4/8, 18/9/12, and 15/0/1 plants $m^{-2}$ respectively. In addition, 20 seeds each of several weeds were sown inside cloth bags and were submitted to the treatment. The efficiency of biofumigation combined with solarization in the control of *P. oleracea, Cynodon dactilon* and *Echinochloa crus-galli* was 77/0, 50/15, and 30/2, as a percentage of germination of control/BF+S. Laboratory experiments consisted of simulating field conditions using a mix of soil, water and different fresh organic matter in a plastic bag, into which different seeds were sown and kept under controlled conditions over 30 days at 27ºC. Fresh organic matter used was whole strawberry plants, horse manure, hen droppings, and combinations of these. Best results were obtained with hen droppings, which showed effective control of *Malva parviflora*, *Medicago* sp., *E. crus-galli*, *Amaranthus retroflesuxus*, *Chenopodium album* and *P. oleracea*, while strawberry residues and horse manure were not useful as herbicides, sometimes even less so than the solarization treatment. Biofumigation with fresh hen droppings and solarization showed promising results in preliminary experiments.**



## INTRODUCTION

Strawberry is a very important crop in Spain, with a growing area of 9,775 ha and a production of 315,000 t in 2003 (FAO, 2003). Spain is the second largest strawberry producer in the world, mainly in the province of Huelva, which produces 89% of Spanish strawberries.

Effective weed management in strawberries requires a combination of cultural practices, preplant soil fumigation, and herbicide applications when necessary. Proper field and bed preparation is essential for a good weed control program. Fumigation with methyl bromide and the use of plastic mulches are common methods of weed control in strawberries. However, according to The Montreal Protocol and EC Regulation

2037/2000 on Substances That Deplete the Ozone Layer, the use of methyl bromide will be allowed only under critical use nomination after 2004.

The search for alternative control methods initiated the study of the properties of biofumigation. During the decomposition of organic matter gases are produced, some of which are toxic to plant diseases, insects, nematodes and weeds. This process is known as biofumigation (Kirkegaard et al., 1993). Even though the concept of biofumigation was applied originally to isothiocyanates produced during *Brassica* spp. decomposition, other research has included organic matter and industry residues that contain biologically active compounds that might suppress soil-borne pests and diseases (Bello et al., 2001). The value of biofumigation for weed control is not as well developed as it is for pest and disease control, but there are several studies concerning the use of *Brassica* spp. green manure (Boydston and Hang, 1995).

The aim of this research was to study the effect of biofumigation with different fresh residues on the germination, growth and distribution of typical weeds of Spanish strawberries under controlled laboratory and field conditions.

## MATERIALS AND METHODS

### Plant Material

Strawberry plants (*Fragaria X ananassa* Duch., var. Camarosa) were used in this study. Seeds of *Echinochloa crus-galli, Chenopodium album, Amaranthus retroflexus, Portulaca oleracea, Cynodon dactilon, Malva parviflora* and *Medicago* sp. were also used to determine the effect of different biofumigation substances.

### Soils and Locations

Field experiments were conducted on typical sandy loams at Almonte and Gibraleon (Huelva, Spain). For laboratory experiments, a mix of different sandy loam soils was used.

### Effect of Biofumigation on Weeds

Twenty seeds of the selected species were mixed in a plastic bag with 500g of soil, 20g or 20+20g of fresh organic material and 60ml of water. Bags were sealed, incubated for 30 days and kept at 27ºC, 16-h photoperiod of 350 kmol m-2 s-1 PPFD, and at 80% relative humidity (Díaz-Viruliche, 2001). Biofumigation materials used were hen droppings, horse manure, strawberry residues and a mix of these. Control bags without organic matter simulated solarization.

An additional experiment under controlled field conditions was carried out by placing 20 seeds of each weed species in a cloth bag and submitting it to field fumigation with hen droppings and solarization for 40 days. After this time, seeds were kept at room temperature for 30 days, after which they were sown in pots and kept under controlled conditions as described previously.

Field experiments consisted of treatment with hen droppings or horse manure at a rate of 3 kg $m^{-2}$ over 45 days at two locations (Almonte and Gibraleon, Huelva, Spain). Biofumigation was applied alone or in combination with solarization. After this time plastic covers were removed, and during the next 30 days the land was prepared for the crop. The experiment consisted of a randomized block design with three replicates in each area. Data were recorded monthly.

## RESULTS AND DISCUSSION

Results obtained from the laboratory experiment showed that hen droppings used as the biofumigant produced the best results, with efficient control of *Malva parviflora*, *Medicago* sp., *Echinochloa crus-galli*, *Amaranthus retrofluxus*, *Chenopodium album* and *Portulaca oleracea*, preventing the germination of seeds. By contrast, strawberry residues and horse manure favoured the growth of *Medicago* sp., *Echinochloa crus-galli* and *Portulaca oleracea*. However, they may be beneficial in combination with the high temperatures developed under solarization during the hot Spanish summer. Under these conditions the plants were killed, but control of the weeds was not achieved in the growth chamber (Table 1).

The controlled field experiment showed the efficiency of biofumigation in combination with solarization, good control of *Portulaca oleracea, Cynodon dactilon* and *Echinochloa crus-galli* being achieved with a germination percentage of control/BF+S of 77/0, 50/15 and 30/2, respectively (Fig. 1).

Field biofumigation with horse manure did not show significant differences between the control and treatments, even in combination with solarization. These are the results of the first year and, and further trials will be carried out.

By contrast, biofumigation with hen droppings showed good control of the main weed species, *Poa annua, Portulaca oleracea* and *Lolium rigidum*, with results of control/BF/BF+S of 42/4/8, 18/9/12, and 15/0/1 plants $m^{-2}$, respectively. The effect of biofumigation on control of weeds is clearly positive, mainly in the earlier months when significant control was achieved in the biofumigation experiment. No significant differences were observed with or without solarization (Fig. 2).

## CONCLUSION

The efficacy of *Brassica* spp. as a biofumigant has been demonstrated (Boydston and Hang, 1995), and other residues could be used for pest control, reducing the use of pesticides and providing a new use for these products and improving the environment.

The results of this research have shown that the utilization of fresh hen droppings could be useful for weed control in strawberry fields, providing good control of *Portulaca oleracea*, *Echinochloa crus-galli* and *Cynodon dactilon*, while the use of horse manure did not control weeds. Further research is being carried out in order to obtain a better understanding of the phenomenon of biofumigation and its herbicidal properties.

## ACKNOWLEDGEMENTS

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## Table

Table 1. Percentage germination of weeds after 28 days of biofumigation with different residues. Data are means of two experiments with three replicates.

| | ***Malva* sp.** | ***Medicago* sp.** | ***Echinochloa* sp.** | ***Portulaca* sp.** | ***Amaranthus* sp.** |
|---|---|---|---|---|---|
| Solarization | 4,15 | 5,85 | 3 | 12,5 | 0,85 |
| Strawberry | 0 | 18,35 | 9,5 | 29,15 | 2,5 |
| Hen dropping | 0 | 0 | 5,85 | 6,65 | 1,65 |
| Straw + HD | 0 | 0 | 3,35 | 0 | 0,85 |
| Horse manure | 5,0 | 25,0 | 21,7 | 41,7 | 0,0 |
| Straw + HM | 6,7 | 26,7 | 6,7 | 33,3 | 0,0 |

Straw: strawberry rest
HD: hen droppings
HM: horse manure

## Figures

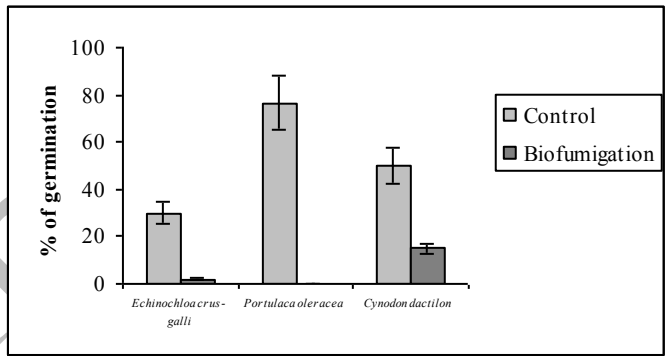


Fig. 1. Effect of a controlled field biofumigation with hen droppings on germination of *Echinochloa crus-galli*, *Portulaca oleracea* and *Cynodon dactilon*. Data are means of three replications.

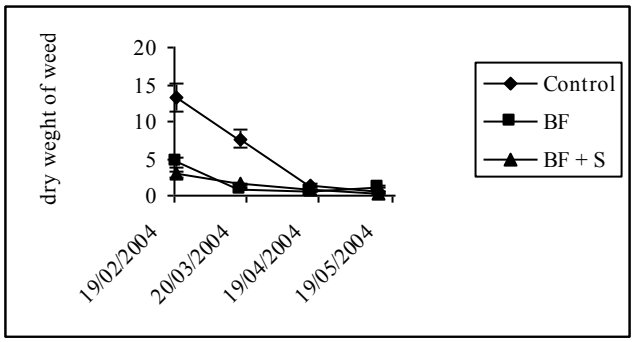


Fig. 2. Effect of biofumigation in Almonte with fresh hen droppings on the dry weight of different strawberry weeds. Data are means of three replications.