# ALLELOPATHIC EFFECT OF SAGE ON GERMINATION AND INITIAL GROWTH OF MAIZE

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## ABSTRACT

*Salvia officinalis L. (sage) is a medicinal plant cited for its strong allelopathic effects. This plant is being studied for its pesticidal potential and much less for its biostimulant activities. The development of new biostimulants in the context of sustainable crop management, is necessary. The aim of the study was to determine allelopathic effect of sage on germination and initial growth of maize (Zea mays L.) Two experiments were conducted under laboratory conditions to determine effect of cogermination of sage and maize seeds and effect of sage aqueous extracts from fresh and dry sage biomass in concentrations of 5%, 10% and 20%, were investigated. Sage seeds in cogermination with maize and aqueous extracts of sage showed not significant effects on germination percentage, but showed significant effects on maize seedlings. The shoot and root length was strongly inhibited by cogermination. On the contrary, shoot length of maize was stimulated by the lowest concentration of extracts (5%), while it was inhibited by higher concentration (20%). For the root length, a slight stimulation (not significant) was observed at the 5% and 10% concentrations of sage extracts, while it was inhibited by 20% concentration. It can be concluded that dilute concentrations of sage can be utilized as a natural source (biostimulants) for initial growth of maize.*

## INTRODUCTION

*Salvia officinalis* L. (sage) is a perennial medicinal plant used by humans and it is considered a universal panacea (Muntean et al., 2007). The genus Salvia (Labiatae family) consists of about 900 species of which 15 are distributed in the Romanian flora (Ciocarlan, 2009). The ethnomedicine and its medicinal value is based on the volatile oils concentration (Sarac and Ugur, 2007). Oniga et al. (2010) reported that the monoterpenoid ketones' presence (á-thujone, â-thujone, camphor) in high amounts in the essential oils of Romanian sage may develop toxicity for these products and may limit their medicinal use.

The volatile oil is important in pesticide, pharmaceutical, flavouring, perfumery and cosmetic industries (Ozkan, 2008). According to Cruz-Silva et al. (2016), the medicinal plants with essential oils in their composition have typically been shown to be promising in plant control. So far, the attention of researchers has focused on their pesticidal properties and much less their biostimulant activities. Therefore, futher attention should be paid to these plant active compounds and their allelopathic effects for the development of new biostimulants in the context of sustainable crop management.

Allelopathy is a phenomenon of chemical interactions among some plants, and allelochemicals are chemicals released from one plant into the environment and these can influence the germination and growth of neighboring plants (Rice, 1984).

The development of allelopathy in agricultural crops represents a challenge for bioengineering and biotechnology (Bonciu and Sarac, 2017). The application of plant extracts could as well inhibit or stimulate the plantlets growth, due to the presence of allelochemicals (Maraschin-Silva and Aquila, 2006).

For a sustainable agriculture, numerous researchers recommend use the allelopathic plants that release allochimics as an alternative to the use of pesticides (Pandia et al., 2014; Ravlic et al., 2016). The different pesticides currently used in agriculture can reduce the germination and the mitotic index and induces a large number of chromosomal anomalies, which suggests its toxic and mutagenic potential (Bonciu, 2012; Bonea and Bonciu, 2017).

The allelopathic effect may be inhibitory or stimulatory and depends on the donor species, the receptor species and the concentrations used.

The biostimulatory effects of these Salvia species have been less studied and especially the effect of cogermination. So far, we have not found such studies.

Therefore, the aim of the study was to determine allelopathic potential of sage on maize through cogermination and use of aqueous extracts.

## MATERIALS AND METHODS

Two experiments were conducted in 2017 in the Laboratory of Plant Breeding at the Faculty of Agronomy, Craiova.

Seeds of sage (*Salvia officinalis* L.) were purchased from Seed Company AGROSEL Cluj. Maize seed (hybrid Olt) from A.R.D.S. Simnic was used in the germination test.

All seeds were surface-sterilized for 20 min with 1% NaOCl (4% NaOCl commercial bleach), then rinsed three times with distilled water (Siddiqui et al., 2009). Aboveground mass of sage collected, during 2017 at flowering stage, from Banu Maracine Didactic Station and were dried at room temperature (25-30°C).

In the first experiment the effect of cogermination of sage and maize seeds was investigated according to Dikic (2005). In each treatment 30 seeds of maize and 30 seeds of sage were placed in Petri dishes on top of filter paper soaked in distilled water. Control treatments consisted of 30 seeds of a single species per dish, respectively maize. The Petri dishes were kept at room temperature (23 °C ± 2) for 7 days.

In the second experiment the effect of sage aqueous extracts on maize was evaluated. The extracts were prepared according to Norsworthy (2003) from fresh and dry aboveground mass of sage. Aqueous extracts were prepared by mixing 100 g of plant powder with 1000 ml of distilled water and kept for 24 h at room temperature. This mixture was filtered through filter paper and the obtained extracts were diluted with distilled water to obtain three final concentrations of 5% (V2), 10% (V3) and 20% (V4). Twenty seeds were placed in sterilised plastic casseroles on top of filter paper. In each casserole was added 15 ml of aqueous extract, while distilled water was used in control (V1). The plastic casseroles were kept at room temperature (23°C ± 2) for 7 days. All treatments had three replications.

*Germination percentage* was calculated for each replication using the formula:

G = (Germinated seed/Total seed) x 100

After eight days, the allelopathic effect was evaluated by measuring the root and shoot length (cm) of seedlings.

*Response index (RI)* was calculated applying the following formulas:

RI = 1 - *(*C/T*)* (If T>C)

RI = (T/C) - 1 (If T<C)

RI ranges from -1 to +1, with positive values indicating stimulation by the treatments and negative values indicating inhibition relative to the controls.

The collected data were analysed statistically with ANOVA and differences between treatment means were compared using the LSD-test at probability level of 0.05.

## RESULTS AND DISCUSSIONS

Results of variance analysis (ANOVA) for cogermination experiment showed that germination percentage was not significantly affected by seeds of *Salvia officinalis* L. However, cogermination affected seedlings growth (root and shoot length) (Table 1).

Shoot and root length of maize was significant reduced with sage seeds (Table 2).

**Table 1.** ANOVA for studied traits of maize at cogermination with sage seeds

| Traits | SS | df | MS | F |
|---|---|---|---|---|
| Germination percentage (%) | 16.66 | 1 | 16.66 | $0.04^{ns}$ |
| Shoot length (cm) | 10.40 | 1 | 10.40 | 10.68* |
| Root length (cm) | 15.68 | 1 | 15.68 | 9.37* |

*, ns = Significant and not significant at p ≤ 0.05

**Table 2.** Effect of cogermination on seedlings growth of maize

| Treatment | Shoot length (cm) | Root length (cm) |
|---|---|---|
| Control | 5.66 | 9.66 |
| Cogermination (sage + maize) | $3.03^{0}$ | $6.43^{0}$ |
| LSD 5% | 2.22 | 2.91 |

$^{0}$ = Significant at LSD 5%

A negative value of the Response index (RI<0) showed that the cogermination with sage seeds slight inhibited the germination percentage (0.4%), but strongly inhibited the shoot and root length of maize (46% and 33%, respectively) (Figure 1).

There are no previous experimental results representing the cogermination effect of *Salvia officinalis* on the germination and growth in maize seedlings. However, it is known from the speciality literature that cogermination of aromatic plants and crop seeds can affect differently by stimulating or inhibiting germination and growth, depending on the donor and target species. According Ravlic et al. (2016) the cogermination of sage seeds have inhibitory effect on germination of hoary cress.

Bonea and Urechean (2018) found that the cogermination of *Origanum majorana* with maize seeds has significantly stimulated the germination index (Gi), shoot and root seedlings of maize.

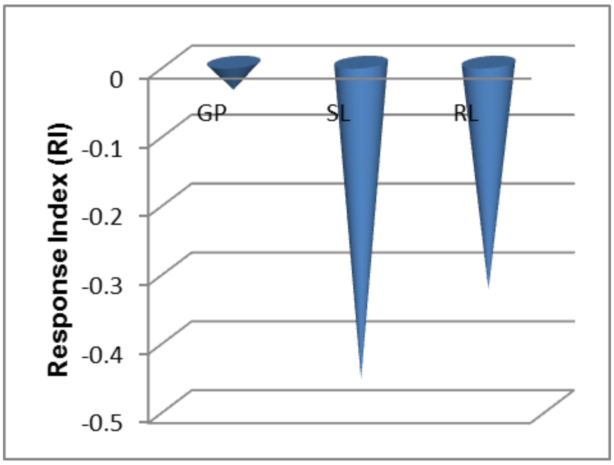


Fig. 1. Inhibition index (RI) of cogermination on germination percentage (GP) and shoot length (SL) and root length (RL) of maize

ANOVA results for studied traits of maize at treatment with aqueous extracts of sage showed that different concentrations of aqueous extracts had not any significant effect on germination percentage (Table 3). However, different treatments affected shoot and root length of maize. Previous studies showed that aqueous extract of aerial parts of *Salvia officinalis* has strong allelopathic effect on seeds germination percentage and root and stem length on barley and purslane (Bajalan et al., 2013).

**Table 3.** ANOVA for studied traits of maize at treatment with aqueous extracts of sage

| Traits | SS | df | MS | F |
|---|---|---|---|---|
| Germination percentage (%) | 691.66 | 3 | 230.55 | $0.79^{ns}$ |
| Shoot length (cm) | 78.26 | 3 | 26.08 | 8.08* |
| Root length (cm) | 251.09 | 3 | 83.69 | 7.72* |

*; ns = Significant and not significant at $p \leq 0.05$

Results showed that the shoot lenght for V2 (5% treatment) was significant higher than that of other treatments. The root length for V2 (5% treatment) was higher than that of other treatments, but there was not any significant difference between control and this treatment. The lowest value for both traits (shoot and root length) belonged to the highest concentration of aqueous extract i.e. V4 (20% treatment) (Table 4). So, the increase in sage aqueous extracts concentration was decrease of the shoot and root length of maize.

A positive (RI>0) and negative (RI<0) value of the Response index showed that the 5% concentration of aqueous extracts slight inhibited the germination percentage (25%), but strongly stimulated the shoot (41%) and root length (37%) of maize. The 10% concentration slight inhibited the germination percentage and shoot lenght (0.4% and 0.5%, respectively), but had slight stimulatory effects on root length of maize (24%). The 20% concentration strongly inhibited growth of shoot and root seedlings (60% and 68%, respectively) (Figure 2).

**Table 4.** Effect of sage aqueous extracts on seedlings growth of maize

| Variant | Treatment | Shoot length (cm) | Root length |
|---|---|---|---|
| V1 | Control | 5.66 | 9.66 |
| V2 | 5% | 9.46* | 15.23$^{ns}$ |
| V3 | 10% | 5.36$^{ns}$ | 12.70$^{ns}$ |
| V4 | 20% | 2.26$^{0}$ | 3.00$^{0}$ |
| | LSD5% | 3.37 | 6.19 |

$^{0}$, ns = Significant and not significant at at LSD 5%

Akpan et al. (2017) reported that the aqueous extract of *Lycopodium clavatum* have stimulatory effect on plumule length and inhibitory effect on radicle length of *Zea mays.* Other studies have shown that the aqueous extracts of oregano in a concentration of 2 and 4% have not affected the percentage of germination, but have significantly inhibited root elongation and fresh weight of maize (Vasilakoglou et al., 2011). According to Bonea et al. (2018), all extracts of *Ambrosia artemisiifolia*, in particularly the 10% concentration, significantly inhibited the germination seeds and had a different effect on the growth of maize seedlings. Husna et al. (2016) found that the growth of plumule and radicle of the test wheat, sorghum and maize was strongly inhibited by almost all the extracts of *Salvia plebeia.*

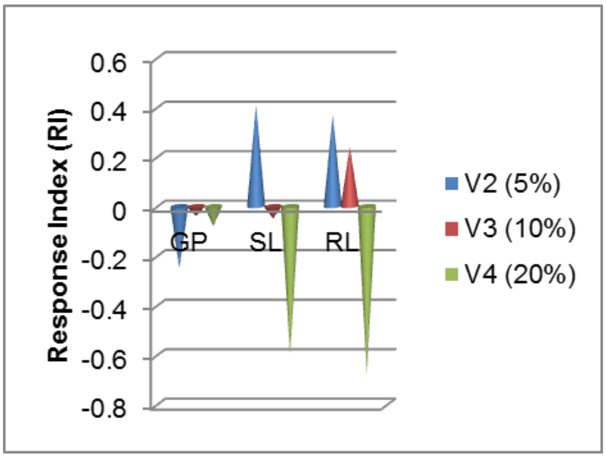


Fig. 2. Inhibition or stimulation index (RI) of aqueous extracts on germination percentage (GP) and shoot length (SL) and root length (RL) seedlings of maize

## CONCLUSIONS

The results obtained in this study indicate that *Salvia officinalis* has allelopathic effects on the maize, varying according to the method (cogermination or extracts) and the concentration used.

Sage seeds in cogermination with maize and aqueous extracts of sage showed not significant effects on germination percentage, but showed significant effects on maize seedlings.

The growth of shoot and root of the maize was strongly inhibited by cogermination. On the contrary, shoot length of maize was stimulated by the lowest concentration of extracts (5%), while it was inhibited by higher concentration (20% ). For the root length, a slight stimulation (not significant) was observed at the 5% and 10% concentrations of sage extracts, while it was inhibited by 20% concentration. It can be concluded that dilute concentrations of sage can be utilized as a natural source (biostimulants) for initial growth of maize.

## BIBLIOGRAPHY


Akpan E.N., Denise E.M., Ezendiokwelu E.L., Anyadike M.C., 2017. *Growth response of seedlings of zea mays (L.) to aqueous extract of lycopodium clavatum (L.)*. MOJ Biol Med., 2 (4): 287–289.

Bajalan I., Zand M., Rezaee S.H., , 2013. *Allelopathic effects of aqueous extract from Salvia officinalis L. on seed germination of Barley and Purslane.* International Journal of Agriculture and Crop Sciences, 5 (7): 802-805.

Bonciu E., 2012. *Cytological effects induced by Agil herbicide to onion*. Journal of Horticulture, Forestry and Biotechnology, Volume 16 (1): 68-72.

Bonciu E., Sărac I., 2017. *Implications of modern biotechnology in the food security and food safety*. Annals of the University of Craiova - Agriculture, Montanology, Cadastre Series, 46 (1): 36-41.

Bonea D., Bonciu E., 2017. *Cytogenetic effects induced by the fungicide Royal Flo to maize (Zea mays L.)*. Caryologia, 70 (3): 195-199.

Bonea D., Bonciu E., Niculescu M., Olaru A.L., 2018. *The allelopathic, cytotoxic and genotoxic effect of Ambrosia artemisiifolia on the germination and root meristems of Zea mays.* Caryologia, 71 (1): 24-28.

Bonea D., Urechean V., 2018. *Effect of sweet marjoram (Origanum majorana L.) cogermination and aqueous extracts on maize (Zea mays L.)*. ”Agriculture for Life, Life for Agriculture” Conference Proceedings, 1 (1): 11-16. **DOI:** https://doi.org/10.2478/alife-2018-0002

Ciocarlan, V., 2009. *Flora ilustrată a României. Pteridophyta et Spermatophyta.* Ed. Ceres, Bucureşti, p: 656-660.

Cruz-Silva C.T.A., Nóbrega L.H.P., Dellagostin S.M., Silva C.F.G., 2016. *Salvia officinalis L. coverage on plants development*. Revista Brasileira de Plantas Medicinais, 18: 488-493.

Dikic M., 2005. *Allelopathic effect of cogermination of aromatic and medicinal plants and weed seeds*. Herbologia, 6 (1): 15-24.

Husna M.S., Aqib S., Shabeena L.A.I., Humaira G., 2016. *Allelopathic Effect of Salvia plebia R. Brown on germination and growth of Zea mays var. 30-25 hybrid, Triticum astivum var. Pirsabak-04 and Sorghum bicolor L.* J. Appl. Environ. Biol. Sci., 6 (4): 93-104.

Maraschin-Silva F., Aquila M.E.A., 2006. *Contribution to the study of native species allelopathic potential*. Revista Arvore, 30: 547-555.

Muntean L.S., Tamas M., Muntean S., Muntean L., Duda M, Varban D.I., Florian S., 2007. *Tratat de plante medicinal cultivate şi spontane*. Ed. Risoprint, Cluj-Napoca.

Norsworthy J.K., 2003. *Allelopathic potential of wild radish (Raphanus raphanistrum).* Weed Technology, 17: 307-313.

Oniga I., Oprean R., Toiu A., Benedec D., 2010. *Chemical composition of the essential oil of Salvia officinalis L. from Romania.* Rev. Med. Chir. Soc. Med. Nat., 114 (2): 593-599.

Ozkan M., 2008. *Glandular and eglandular hairs of Salvia recognita Fisch. and Mey. (Lamiaceae) in Turkey.* Bangladesh Journal of Botany, 37: 93-95.

Pandia O., Saracin I., Bogza I., 2014. *The ecological control of pests at cabbage using Artistolochia Clematitis plants from spontaneous* *flora.* Agrarian Economy and Rural Development – Realities and Perspectives for Romania, 5: 202-206.

Ravlic M., Balicevic *R., Nikolic M., Sarajlic A., 2016. Assessment of allelopathic potential of fennel, rue and sage on weed species hoary cress (Lepidium draba).* Notulae Botanicae Horti Agrobotanici Cluj-Napoca, 44 (1): 48-52.

Rice E.L., 1984. *Allelopathy*. Ed. 2, Orlando, FL, p 422.

Sarac N., Ugur A., 2007. *Antimicrobial activities and usage in folkloric medicine of some Lamiaceae species growing in Mugla, Turkey*. Eur. Asia J. Bio. Sci., 1: 28-34.

Siddiqui S., Bhardwaj S., Khan S.S., Meghvanshi M.K., 2009. *Allelopathic effect of different concentration of water extract of prosopsis Julifloral eaf on seed germination and radicle length of wheat (Triticum aestivum Var-Lok-1)*. American-Eurasian Journal of Scientific Research, 4 (2): 81-84.

Vasilakoglou I., Dhima K., Anastassopoulos E., Lithourgidis A., Gougoulias N., Chouliaras N., 2011. *Oregano green manure for weed suppression in sustainable cotton and corn fields*. Weed Biology and Management, 11: 38–48.