EFFECT OF THE AQUEOUS EXTRACTS OF *AMORACIA RUSTICANA* L. ON THE SEED GERMINATION AND SEEDLING GROWTH OF *ZEA MAYS* L. UNDER DROUGHT STRESS

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ABSTRACT

Horseradish (Armoracia rusticana L.) is a perennial plant cultivated all over Europe, having an allelophatic *effect on the germination and seedling growth at many species of plants. The experiment described in this paper examines a series of concentrations of aqueous extracts of horseradish roots in conditions of drought stress induced by NaCl, at maize. The effects of the extracts were significant on final germination rate (Gr), shoot length (SL) and root length (RL). The extracts having concentrations of 10% and 15% had a significant stimulating effect on the studied traits, and the increase of the concentration of the aqueous extracts to 20% caused the inhibition of these traits. Therefore, the aqueous extracts of horseradish could help germination and seedling growth of maize reducing the negative effect of drought stress.*

INTRODUCTION

In 1996, the International Allelopathy Society defines allelopathy as "*any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influences the growth and development of agriculture and biological systems*" (IAS, 1996).

Horseradish (*Armoracia rusticana* L.) is a perennial plant, belonging to the Brasicaceae Family, which has a strong allelopathic potential. This potential is given by the content of glucosinolates (GLS), especially isothiocyanates (Reau et al., 2005). In literature it is stressed the fact that the allelopathic influence of plant extracts depends on various factors, one of them being concentration. Researchers have generally ignored the stimulating effects of allelochemicals because these effects are not as significant as the inhibition effects (Abbas et al., 2013).

Nevertheless, some studies report stimulating effects of some plants on other plant species. Al-Sherif et al. (2013) showed that the toxicity of *Brassica nigra* extracts was caused by the phenolic compounds which inhibited seed germination and seedling growth, but the low level concentration of *Brassica nigra* ethanol extract had a stimulating effect on the target species. Sahoo et al. (2010) reported significant stimulating effects on the length of maize shoot and root, after using 40% concentration aqueous extracts of *Mangifera indica L.* Hegab et al. (2016) reported that the lower level of Eucalyptus treatment (0.5 %), induced a stimulatory effect on the growth of shoot and root of maize plants.

Allelochemicals are present in all types of tissues, having a high potential of use as herbicides (Sing, 2003), but also as growth promoters (Chon and Kim, 2002). Some plants can influence the growth of other plants by simply their growing next each to other and this influence is translated, at the same time, in the environmental protection (Bonciu, 2012).

Drought is one of the most important abiotic stresses, which limits crop production in different parts of the world (Shao et al., 2009). In Oltenia, maize crop is frequently affected by drought (Urechean et al., 2010).

This paper presents the allelopathic effect of the aqueous extracts of *Armoracia rusticana* L. roots on the germination and seedling growth of *Zea mays* under drought stress.

MATERIALS AND METHODS

Horseradish aqueous extracts were obtained as follows: the horseradish root (collected in March) is grated and covered with distilled water, the ratio being 1:2. This mixture is kept to soak for 12 hours, then the liquid is pressed out and filtered through double filter paper. The extract thus obtained, considered to have a 100% concentration, is refrigerated for 3 days and then distilled with distilled water till reaching 5%, 10%, 15% and 20% concentration solutions (Corbu et al., 2007).

Maize seeds were set to germinate in sterilised plastic casseroles, on filter paper, three casseroles being allotted for each treatment. The seeds under study were moistured with 10 ml/per casserole of the watery solutions obtained by dilluting the horseradish extract; the control casserole seeds were moistured with 10 ml of distilled water. The mentioned concentrations were added the stress factor, i.e. 10 ml NaCl (5 g/l) per each casserole, including the control casserole (CT). The casseroles were put in the germinator, there, they were kept in the dark, at a temperature between 23^0-25^0 C. The effects of the horseradish aqueous extracts on the maize germination and growth were calculated applying the following formulas:

Final germination rate (Gr) %:

$Gr = \Sigma Gt/Nt \times 100\%$

Gr = the percentage of emerged seedlings/total number of seeds sown; Gt = the seedling number at day t, Nt = the total number of seeds sown

Germination speed index (Gi)

$Gi = \Sigma (G^t/D_t)$

G*i* = the seed germination speed of the species; G^t = seedling number at day t, D_t = the number of days when seedling numbers were recorded.

Vigor index (Vi)

$Vi = Gi \times S$

Vi = the ability of seeds to germinate; Gi = the germination speed, S = the seedling length (cm).

Response index (RI)

$RI = 1 - (C/T)$ (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 significance of the differences was calculated for the 0.05 probability, using the LSD test.

RESULTS AND DISCUSSIONS

1.Seed germination

The results regarding the seed germination variance analysis (Table 1) showed that the aqueous extracts of *Armoracia rusticana L.* influenced significantly only the Final germination rate (Gr), but not Germination speed index (Gi) or Vigor index (Vi).

Table 1

Variance analysis of studied traits of *Zea mays* L

Traits	SS	df	MS	F
Final germination rate (Gr)	7173.3	4	1793.3	4.9*
Germination speed index (Gi)	49.3	4	12.3	2.6^{ns}
Vigor index (Vi)	3713.5	4	928.3	2.7^{ns}
Root length (RL)	8	4	2	8*
Shoot length(SL)	61.2	4	15.3	7.5*

ns =Non-significant, * = Significant at p 0.05

Even if there was no noticeable effect of the extracts when they had concentrations of 10% or 15% (Figure 1), when expressed relative to the seeds on the control treatment, RI of Gr was positive (Table 2). The increase of the extract concentration up to 20% inhibited significantly the final germination rate, compared to the control treatment (Figure 1, Table 2)

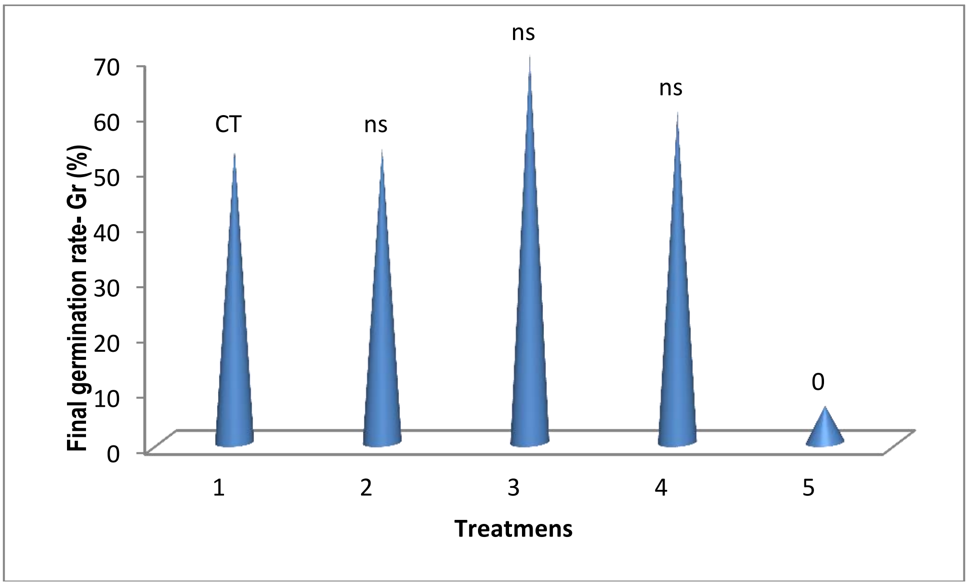

Fig 1. Effects of *Armoracia rusticana* aqueous extracts and drought stress on seed germination rate (Gr); **LSD 5% = 34.5%**

Table 2

Inhibition or stimulation (RI) index of aqueous extracts on maize seed germination rate under drought stress

No.	Treatments	RI of Gr
1	CT (NaCl)	-
2	5% + NaCl	0
3	10% + NaCl	+0.24
4	15% + NaCl	+0.11
5	20% + NaCl	-0.87

2. Seedling growth

The variance analysis for seedling growth showed a significant effect both in the case of shoot length and of root length in drought conditions (Table 1). The *Armoracia rustica* extracts having concentrations of 10% and 15% stimulated significantly the growth of the shoot length (RI>0) compared to the control (Figure 2, Table 3).

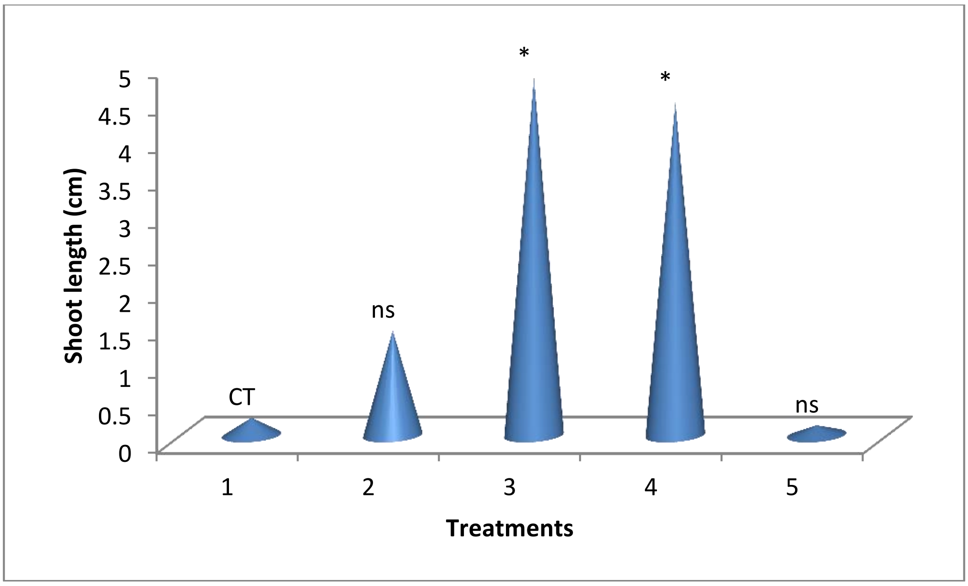

Fig 2. Effects of *Armoracia rusticana* aqueous extracts and drought stress on shoot length (SL); LSD 5% = 2.58 cm

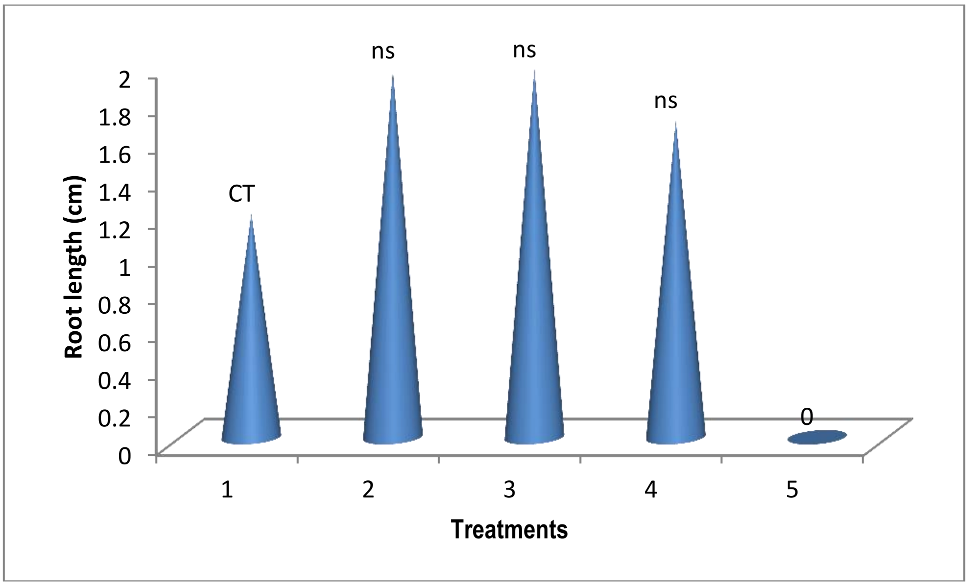

Fig 3. Effects of *Armoracia rusticana* aqueous extracts and drought stress on root length (RL); LSD 5% = 0.89 cm

There were no significant effects for the 5% concentration extract (Figure 2), but a stimulating effect was noticed (RI>0) (Table 3). Increasing the concentration to 20% had an inhibiting (Table 3), but insignificant effect on the shoot length (Figure 2).

Table 3

Inhibition or stimulation (RI) index of aqueous extracts on maize seedling growth under drought stress

No.	Treatments	RI of SL	RI of RL
1	CT (NaCl)	-	-
2	5% + NaCl	+0.84	+0.39
3	10% + NaCl	+0.95	+0.39
4	15% + NaCl	+0.95	+0.29
5	20% + NaCl	-0.43	0

As far as the root length is concerned (Figure 3), there were no statistically significant effects for concentrations of 5%, 10% and 15%, in spite of the fact that they caused a stimulating effect (RI>0) (Table 3). The highest concentration extract (20%) inhibited significantly root length growth.

The stimulating or inhibiting effects of *Armoracia rusticana* extracts depend on the concentrations used, but also on the sensitivity of the receiving species. Thus, a 25% concentration stimulated germination and shoot length with *Triticosecale* Witt, but inhibited both germination and shoot length with *Triticum aestivum* L (Şipoş et al., 2012). In our case, for *Zea mays* , the 20% concentration had an inhibiting effect on all the traits studied.

The stimulating effect of the 10% and 15% concentration *Armoracia rusticana* extract was more effective (significant) on the shoot length than on the root length.

Qian et al. (2010.) and Şipoş et al. (2012) consider that roots are more sensitive than shoots to allelochemicals. Corbu et al. (2008) reported that aqueous extracts from horseradish roots having a 5% or 15% concentration stimulated the peroxidasic activity of the roots of wheat, ryegrass and brome grass inaristata, and the intensification of the peroxidasic activity is an attempt of plants to protect themselves against the stress.

CONCLUSIONS

In conditions of drought stress, final germination rate *(Gr*) was stimulated by the aqueous extracts of horseradish having a concentration of 10%, respectively 15%, but increasing the concentration to 20% caused a significant inhibition.

The shoot and root length was significantly stimulated by 5%, 10% and 15% concentrations, but the 20% concentration watery extracts caused a noticeable inhibition of maize seedling growth.

Aqueous extracts of horseradish can be used both as biostimulators and herbicides, depending on their concentration and on the receiving species, that is why it is absolutely necessary to establish exactly the limit between the stimulating and the inhibiting concentrations.

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