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Original Article

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SURVEY THE ALLELOPATHIC EFFECTS OF TOBACCO (*NICOTIANA TABACUM* L.) ON CORN (*ZEA MAYS* L.) GROWTH AND GERMINATION

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ABSTRACT. Allelopathy is the direct influence of chemical released from one plant on the development and growth of another plant. The trial accomplished in seed technology laboratory of Faculty of Agriculture, Islamic Azad University of Isfahan, in 2018. A factorial layout within completely randomized design with four replications was used. Treatments included plant organs extract (leaf, stem, root and total plant), and different tobacco extract densities includes four levels of 0%, 25%, 50% and 100%. Control treatment (0% of tobacco extract) had obtained the highest value of germination rate, germination percentage, coleoptile weight, radicle weight, radicle length and coleoptile length. The maximum germination rate, germination percentage, coleoptiles weight, radicle weight, radicle length and coleoptiles length was related to extract of stem extract which had meaningful differences with other treatments. Both radicle and coleoptile length decreased with increase in concentration of tobacco extract. Tobacco extract has negatively effects on corn seeds by decreasing the germination rate. Tobacco may increase the presence of secondary metabolites, such as alkaloids, all of which may have different effects on seed germination percentage. The highest germination percentage (91.91%), coleoptile weight (0.046 mg), radicle weight (0.0161 mg), radicle length (7.24 mm), and coleoptiles length (6.45 mm) was related to interaction between control treatment (0% of extract) and stem extract. It is concluded that the extract of *Nicotiana tabacum* had both inhibitory and stimulatory effects on seedling growth of *Zea mays*.

Keywords: radicle length; radicle weight; organ extract; coleoptile length; coleoptile weight.

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INTRODUCTION

Corn (*Zea mays L.*) is an important annual cereal and it is the third important food crop in the world (Broumand *et al.,* 2010; Khoshkharam *et al.,* 2010; Esfandiary *et al.,* 2011; Soleymani *et al.,* 2011; Esfandiary *et al.,* 2012; Soleymani and Shahrajabian, 2012a,b; Soleymani *et al.,* 2012a,b; Soleymani and Shahrajabian, 2013; Soleymani *et al.,* 2016; Shahrajabian et al., 2017). Plants secrete different types of secondary metabolites, which influence the growth and development of the surrounding plants and microbes by a process called allelopathy, which plays a significant role in agroecosystems, and affects the growth, quality and quantity of the produce (Ogbaji *et al.,* 2013; Norouzi *et al.,* 2016: Shahrajabian *et al.,* 2019a,b,c,d). Allelopathy is an interference mechanism in which living or dead plants release allelochemicals exerting an effect on the associated plants, and can play an important role in natural ecosystems (Inderjit and Duke, 2003; Ahmad and Bano, 2013). Ahmad and Bano (2013) reported the delay and reduction of seeds germination and inhibition of root and shoot growth because allelochemicals. Soleymani and Shahrajabian (2018) also reported that germination is the most sensitive stage in the life cycles of plant and uniform germination is essential to having increase in the yield. Tobacco plant is rich in allelochemicals, including isoprenoids, alkaloids, cinnamoylputrescines, flavonoids and anthocyanins (Nugroho and Verpoorte, 2002; Farooq *et al.,* 2014). Mushtaq and Siddiqui (2018) found that delayed seed germination and slow root growth, attributable to the extracts, maybe baffled with diffusion effects on the rate of imbibition, delayed initiation of germination and particularly cell elongation.

Farooq *et al.* (2014) has found that allelopathic chemicals from tobacco negatively impacts mung bean growth. Therefore, the objective of the present studies was to investigate the allelopathic effect of tobacco (*Nicotiana tabacum* L.) on germination and early growth of corn.

MATERIAL AND METHODS

This research accomplished in seed technology laboratory of Faculty of Agriculture, Islamic Azad University of Isfahan, Iran, in 2018 (latitude 32°40'N, longitude 51°58'E and 1570 m elevation). A factorial layout within completely randomized design with four replications was used. Treatments included plant organs extract (leaf, stem, root and total) and different tobacco extract densities (Burley cultivar) includes four levels of 0%, 25%, 50% and 100%. Aerial sections of the plant were separated by scissors. Aerial sections and roots were dried and grind. The achieved 5 g powder has been poured in 100 ml water and has been put during 24 hrs on shaker machine. Then, it was put in centrifuge machine during 15 min with 3000 rotations. The result mixture was filtered by Whatman filter paper (number 2). At first, the seeds of corn (SC 704) were put in sodium hypocoloid 5% during 10 min and then they were washed by distilled water. Seeds soaked in distilled water were used

as control treatment. For germination test, 20 seeds were put in 12 cm Petri dishes on two layers of filter paper and 5 ml of distilled water for control and 5 ml from levels of expected extract were added to it. The lids of containers with the temperature 25°C were prepared (12 hrs in the day and 12 hrs in the night). Every day, the germinated seeds were numbered in the certain hour. The criterion of radical exit germination has been considered 1 mm. At the end of germination test, the length of radical and coleoptiles were measured. Both radical length (root) and plumule (shoot) length was measured using a ruler in cm. Also, at the end, the extreme percent of germination and the rate of germination were accounted. For counting the length of radical and coleoptiles, 10 germinated seeds were sent out from Petri dishes and measured. For accounting germination rate, from the second day, unit when the seeds did not germinate, the germinated seeds were counted per 24 hrs and on time.

The germination rate was defined as following (*Equation 1*):

$$GR = \Sigma \frac{N}{\Sigma(n \times g)} \qquad (1)$$

where, n is the number of germinated seed on growth day and g is the number of germination seeds. Analysis of variance (ANOVA) was used to determine the significant differences. The Multiple Range Test of Duncan performed the separation means ($P< 0.05$). All statistics was performed with the SAS statistical software.

RESULTS AND DISCUSSION

The influence of tobacco extract was significant on coleoptiles weight and coleoptiles length, but germination rate, germination percentage, radical weight and length were not significantly affected by it. Soleymani and Shahrajabian (2012c) also reported the significant influence of sesame extract density on germination rate, germination percentage, coleoptiles weight, radical and coleoptile length. Plant organs had meaningful effect on germination rate, germination percentage, coleoptiles weight, radical weight, radical length, and coleoptiles length.

Soleymani and Shahrajabian (2012c) also mentioned the meaningful effect of plant organ on germination rate, radical weight, radical length and coleoptiles length. The interaction between tobacco extract and plants organs had no meaningful effect on experimental characteristics (*Table 1*).

Yazdani and Bagheri (2011) demonstrated that germination percentage, root and shoot length in soybean in both laboratory and glasshouse experiment were significantly affected by different tobacco root and shoot extracts.

The highest germination rate (2.48%), and germination percentage (78.48%) was related to control treatment, followed by 25%, 50% and 100% of tobacco extract density. All differences between treatments on germination rate and germination percentage were not significant.

Baek *et al.* (2017) concluded that allelopathic chemicals released by tobacco have detrimental effects on the germination of mung bean and red fife wheat. The maximum coleoptiles weight (0.037 mg) and the minimum

one (0.027 mg) was obtained for control treatment (0%) and 100% of tobacco extract density, which had meaningful differences with each other.

Table 1 - Analysis of variance for experimental characteristics

S.O.V	d.f.	Germination rate	Germination percentage	Coleoptile weight	Radicle weight	Radicle length	Coleoptile length
Replication	2	0.938	35.592	0.000026	0.00000001	0.203	0.163
Tobacco extract (a)	3	0.281^{ns}	111.302^{ns}	0.00028^{*}	0.00000425^{ns}	0.575^{ns}	3.173^{*}
Plant organs (b)	3	14.619^{**}	2029.228^{**}	0.000617^{**}	0.00023168^{**}	4.836**	11.053^{**}
a×b	9	0.689^{ns}	101.614^{ns}	0.00005^{ns}	0.00000122^{ns}	0.54^{ns}	1.298^{ns}
Error	30	1.629	67.187	0.00004	0.00000187	0.312	0.655

^{ns} Non significant; * Significant at 0.05 significant in F-tests;
** Significant at 0.001 significant in F-test

There were no significant differences between 100% of tobacco extract with 25% and 50% of extract density. Radicle weight decreased from control treatment o application 100% of tobacco extract density, but there were no significant differences between treatments. Radicle weight in 0%, 25%, 50% and 100% of tobacco extract was 0.0094 mg, 0.0089 mg, 0.0084 mg, and 0.0080 mg, respectively. The higher value for radical length was achieved in application of 0% of tobacco extract (control treatment) (6.49 mm), followed by 25% (6.22 mm), 50% (6.05 mm) and 100% (6.01 mm) application of tobacco extract density. Moreover, all differences were not significant between treatments. The result of this research is in agreement with Stachon *et al.* (1980) and Akpan *et al.* (2017), which reported that the extracts of allelopathic plants had more inhibitory effect on the root growth than hypocotyls growth because root is the first organ to absorb allelochemical from the environment.

The highest and the lowest value of coleoptiles length was related to 0% (control treatment (4.94 mm), and 25% of tobacco extract density (3.90 mm), which had significant difference with each other.

There was no meaningful difference between application of 25% and 50% of tobacco extract density (*Table 2*). Unlike the results of this experiment, Akpan *et al.* (2017) reported that there was no significant difference in plumule length of corn and it was not significantly affected by the extracts of *L. clavatum*.

Nishida *et al.* (2005) also concluded that the permeability of allelochemicals to root tissue was greater than that of shoot tissue. The

highest germination rate was related to stem extract (3.62 %), which had meaningful difference with all other treatments, except stem extract. Germination rate in leaf, root and total extract was 1.94%, 2.79% and 1.06%, respectively.

Singh *et al.* (2009) also observed that the allelochemicals present in the aqueous leachate of *Nicotiana plumbaginifolia* Viv. delayed germination and reduced seedling growth of *Zea mays* L.

Table 2 - Mean comparison of germination rate (%), germination percentage (%), coleoptile weight (mg), radical weight (mg), radical length (mm) and coleoptile length (mm)

Treatment	Germination rate	Germination percentage	Coleoptile weight	Radicle weight	Radicle length	Coleoptile length
Tobacco extract density (E)						
0% (E1)	2.48^{a}	78.48^{a}	0.037^{a}	0.0094^{a}	6.49^{a}	4.94^{a}
25% (E2)	2.45^{a}	73.7^{a}	0.028^{b}	0.0089^{a}	6.22^{a}	3.9^{b}
50% (E3)	2.33^{a}	73.56^{a}	0.028^{b}	0.0084^{a}	6.05^{a}	4.22^{b}
100% (E4)	2.14^{a}	71.22^{a}	0.027^{b}	0.0080^{a}	6.01^{a}	4.9^{a}
Plant organs (O)						
Leaf (O1)	1.94^{bc}	68.22^{c}	0.026^{c}	0.0064^{c}	6^{b}	3.97^{c}
Root (O2)	2.79^{ab}	80.56^{b}	0.033^{b}	0.008^{b}	6.30^{b}	4.83^{b}
Stem (O3)	3.62^{a}	88.77^{a}	0.039^{a}	0.015^{a}	6.99^{a}	5.66^{a}
Total (O4)	1.06^{c}	59.41^{d}	0.023^{c}	0.0052^{d}	5.47^{c}	3.49^{c}
E×O						
E1O3	3.79^{a}	91.91^{a}	0.046^{a}	0.0161^{a}	7.24^{a}	6.45^{a}
E1O2	2.53^{abc}	79.46^{abcd}	0.037^{abc}	0.0079^{cd}	6.21^{bc}	5.48^{abc}
E1O1	2.01^{abc}	74.02^{bcde}	0.033^{bcd}	0.007^{cdef}	6.19^{bc}	4.16^{cde}
E1O4	1.59^{abc}	68.51^{cdef}	0.032^{bcd}	0.0064^{defg}	6.31^{bc}	3.67^{de}
E2O3	3.41^{ab}	91.08^{a}	0.043^{ab}	0.0160^{a}	7.17^{a}	6.05^{ab}
E2O2	2.95^{abc}	86.18^{ab}	0.033^{bcd}	0.0085^{c}	6.74^{ab}	4.49^{cd}
E2O1	2.49^{abc}	62.44^{efg}	0.019^{ef}	0.0059^{efgh}	5.89^{c}	2.85^{ef}
E2O4	0.96^{bc}	55.12^{fg}	0.015^{f}	0.0052^{fgh}	5.08^{d}	2.2^{f}
E3O3	3.31^{ab}	81.31^{abc}	0.033^{bcd}	0.0142^{b}	6.4^{bc}	4.83^{bcd}
E3O2	2.69^{abc}	77.21^{abcde}	0.031^{bcde}	0.0076^{cde}	6.04^{c}	4.39^{cd}
E3O1	2.32^{abc}	72.32^{bcde}	0.027^{cde}	0.0069^{cdef}	6.05^{c}	4.1^{cde}
E3O4	1.01^{bc}	63.42^{efg}	0.021^{def}	0.0048^{gh}	5.71^{c}	3.54^{def}
E4O3	3.99^{a}	90.79^{a}	0.032^{bcd}	0.0139^{b}	7.15^{a}	5.33^{abc}
E4O2	2.98^{abc}	79.4^{abcd}	0.029^{cde}	0.0079^{cd}	6.21^{bc}	4.95^{abcd}
E4O1	0.94^{bc}	64.08d^{efg}	0.023^{def}	0.0058^{efgh}	5.88^{c}	4.78^{bcd}
E4O4	0.67^{c}	50.6^{g}	0.022^{def}	0.0044^{h}	4.78^{d}	4.55^{bcd}

Common letters within each column do not differ significantly.
E = Tobacco extract, O = Plant organ

The highest value of germination percentage was obtained for stem extract (88.77%), which had meaningful differences with other treatments. Germination percentage in leaf, root and total extract was 68.33%, 80.56% and 59.41%, respectively. Furthermore, all differences between other treatments were significant.

Florentine and Westbrooke (2005) also reported that aqueous extract of tobacco shoots have inhibitory effects on growth and germination of some crops.

The maximum coleoptiles weight (0.39 mg) and radical weight (0.0150 mg) was achieved in stem extract, and the minimum one was related to total extract. Coleoptile weight and radical weight in total extract was 0.023 mg and 0.0052 mg, respectively. The higher value of radical length was related to stem extract (6.99 mm), followed by root (6.30 mm), leaf (6.00 mm), and total extract (5.47 mm), respectively. All differences between treatments were meaningful. The maximum coleoptile length was related to stem extract (5.66 mm), which had significant difference with total extract (3.49 mm). Coleoptile length in leaf and root extract was 3.97 mm, and 4.83 mm, respectively. All differences between treatments were significant (*Table 2*). Nekonam *et al.* (2014) and Norouzi *et al.* (2016) found that all aqueous extracts from *N. tabacum* showed a significant inhibitory effect on the germination, seedling length and weight of redroot pigweed plants.

The highest germination percentage (91.91%), coleoptile weight (0.046 mg), radicle weight (0.0161 mg), radicle length (7.24 mm) and coleoptiles length (6.45 mm) was related to interaction between control treatment (0% of extract) and stem extract. The interaction between 100% of extract and total plant organ extract has obtained the higher value of germination rate (3.99%), compared to those of other treatments (*Table 2*).

CONCLUSIONS

Allelopathic compounds, often considered as plant produced herbicides, can inhibit growth of nearby plants. Allelochemicals produced by one crop species can influence the growth, productivity and yield of other crops of the same crop. These noxious chemicals influence target species in different ways; affecting growth of root and shoot, they may interfere nutrient uptake or they can attack a naturally occurring symbiotic relationship thereby destroying the plant's usable source. Control treatment (0% of tobacco extract) had obtained the highest value of germination rate, germination percentage, coleoptiles weight, radicle weight, radicle length and coleoptile length. The maximum germination rate, germination percentage, coleoptiles weight, radicle weight, radicle length and coleoptiles length was related to extract of stem, which had meaningful differences with other treatments. The results clearly showed that tobacco extracts inhibited seed

germination, root and shoot growth of corn. Given the fact that environmental conditions in the field can be different from results in laboratory and greenhouse, so additional researches are required to evaluate the allelopathic influence under different field conditions.

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