Songklanakarin J. Sci. Technol.
41 (3), 619-623, May – Jun. 2019

http://www.sjst.psu.ac.th

Original Article

Allelopathic effects of leucaena leaves extract (*Leucaena leucocephala* (Lam.) de Wit) on the growth of rice (*Oryza sativa* L.), wrinkle duck-beak (*Ischaemum rugosum* Salisb), and mung bean (*Vigna radiata* (L.) R. Wilczek)

Pudcharaporn Boaprem*

Department of Plant Science, Faculty of Sciences and Agricultural Technology, Rajamangala University of Technology Lanna, Mueang, Phitsanulok, 65000 Thailand

Received: 7 July 2017; Revised: 8 January 2018; Accepted: 28 January 2018

Abstract

The experiment was conducted to study an allelopathic effects of leucaena leaves on growth of rice, wrinkle duck-beak and mung bean. The result showed that different concentrations of the leucaena extracts showed various growth patterns on the selected plant species. The growth of seedling shoot length, root length, dry weight and fresh weight were decreased by increasing concentration of the leucaena leaves extract. In rice and wrinkle duck-beak was found that the inhibition was higher in the root than the shoot growth. In addition, the use of leucaena extracts 1:1 to 1:5 can restrain the growth of wrinkle duck-beak root length 100% at the age of 3 days, but from the age of 7 days, all leucaena extracts completely restrained the wrinkle duck-beak root length. Furthermore, allelopathy of leucaena results can be utilized for the biological weed control and to reduce the use of herbicide in agriculture systems.

Keywords: allelopathy, rice, wrinkle duck-beak, mung bean, Leucaena leaves extract, *Leucaena leucocephala*

1. Introduction

Wrinkle duck-beak or saromacca grass (*Ischaemum rugosum* Salisb.) is propagated by seeds. Seeds do not germinate while submerged, though after emergence they can grow easily under flooded conditions. *I. rugosum* is found in wet conditions, special in direct-seeded rice fields, where it emerges later than many weeds in crop and is favored by shallow flooding (International Rice Research Institute [IRRI], 2016). In 2012, there was a report of an outbreak of weeds resistant to ACCase-inhibiting herbi-cides, which *I. rugosum* Salisb. had resistance to profoxydim (Maneechote, Thantawil, Chaokongjak, Anantanamanee, & Sathuvijan, 2013).

Leucaena (*Leucaena leucocephala* (Lam.) de Wit) was one of ten invasive plant species which inhibits the growth of giant mimosa. (Zungsontiporn & Chongrukthai, 2011). Mimosine is a non-protein amino acid, and is a major compound present in all plant parts of Mimosaceae, which includes leucaena (*L.leucocephala*), *L. glauca*, and other legumes belonging to *Mimosa* sp. Leucaena is popular in intercropping with annual crops, using as a hedgerow, and alley cropping for yield promotion and weed control (Siaw, Kang, & Okali, 1991), reduced the yield of wheat and turmeric but increased the yield of maize and rice (Kumbhar, & Patel, 2016), and leucaena was a less harmful tree than tectona for maize intercropping in agroforestry systems of Mizoram (Sahoo, Upadhyaya, & Meitei, 2007).

There was no mimosine in *Mimosa pigra* L. while mimosine was found present in all parts of *L. leucocephala* Lam. (Bunnag, 1983). The mimosine content in leaves varied among the different leucaena varieties. Hawaii, Salvador, and local variety were found to have the highest mimosine concentration (Senakusp, Bunnag, Kawisarasai, & Suriyajuntratong, 1983). *L. leucocephala* plantations, exhibit a unique pattern of weed exclusion beneath leucaena canopy. Aqueous

*Corresponding author
Email address: omikami76@gmail.com

extracts of leucaena fresh leaves, litter, soil, and seed exudate showed significantly phytotoxic effects on many test species including rice, lettuce, *Acacia confusa*, *Alnus formosana*, *Casuarina glauca*, *Liquidambar formosana*, *Mimosa pudica*. (Chou and Kuo, 1986), and radish under in - vitro condition (Kalpana & Navin, 2015). However, the effect of mimosine was the lowest against plants that were mimosine producers (*M. pudica* and *L. leucocepphala*) (Xuan, Tawata, & Khanh, 2013).

Ishak & Sahid (2014) found that the germination of goat weed (*Ageratum conyzoides*), coat buttons (*Tridax procumbens*) and lilac tassel flower (*Emilia sonchifolia*) were inhibited by the aqueous extracts of both the leaf and seed of *L. leucocephala* and was concentration dependent. Different aqueous extracts concentrations showed various germination patterns of the selected weed species. Seedling length and fresh weight of goat weed, coat buttons and lilac tassel flower were reduced in response to respective increasing concentrations of the seed extracts. The aqueous seed extract showed greater inhibitory effects than that of the aqueous leaf extract. Maximum inhibition by the aqueous seed extract was observed more on the root rather than the shoot growth. Ahmed, Hoque, & Hossain (2008) reported that leaf litters of *L. leucocephala* induced inhibitory effects on germination and growth of two forest crops Sada koroi (*Albizia procera*), Ipil-ipil (*L. leucocephala*) and three agricultural crops falen (*Vigna unguiculata*), chickpea (*Cicer arietinum*) and arhor (*Cajanus cajan*). It was also found that the effect depended on concentration of extract and litterfall, type of receptor species. Higher concentration of the materials had the higher effect and vice versa, and low-dose leaf litter (10 g m^{-2}) had stimulating effect on shoot growth of *C. arietinum*, *V. unguiculata* and *A. procera*.

The allelopathy influence of *Eucalyptus tereticornis*, *Casuarina equisetifolia* and *L. leucocephala* was tested by growing crops of sorghum, cowpea and sunflower on topsoil and rhizosphere soil from plantations of those trees or on field soil either mulched with dry leaves or irrigated with aqueous leaf extracts. Crop germination, root length and dry matter production were depressed. Maximum reductions were obtained with top soil and by the effect of eucalyptus. Sorghum proved most susceptible to these influences (Suresh & Rai, 2012). Parvin, Shapla, & Amin (2011) revealed that inhibition of germination and growth parameters of mung bean and soybean were varied according to different parts of *L. leucocephala* and soil from different place. *L. leucocephala*: T4 (soil watered with aqueous leaf extract) > T1 (top soil) > T3 (soil mulched with dry leaf) > T5 (control/ fresh garden soil) >T2 (root zone soil).

The present study was conducted to determine and understand the allelopathic potential of the *Leucaena leucocephala* leaves extract on the growth of rice, wrinkle duck-beak and mung bean, and it also be used as a basis for controlling weeds and reduce the use of chemical in the agricultural system.

2. Materials and Methods

This experiment was conducted from January to June 2017 to test the effect of fresh leucaena leaves extract on inhibition the growth of rice, wrinkle duck-beak and mung bean by using leucaena leaves extract at 8 levels of concentration (leucaena leaves: water), 0 (water, control), 1: 1, 1: 2, 1: 3, 1: 4, 1: 5, 1:10 and 1:20.

2.1 Preparation of fresh leucaena leaves extract

Firstly, the leucaenna leaves were harvested from the area surrounding Rajamangala University of Technology Lanna, Phitsanulok (RMUTL). Then, chopped them into small pieces, soaked in water (fresh weight/ volume ratio) for 10 days at room temperature. After that, filtering them with the thin cloth 2 times. All three test seeds (rice, wrinkle duck-beak and mung bean) were seeded on germination test paper until their roots grew 5 mm long. Twenty seeds of rice and wrinkle duck-beak, and ten seeds of mung bean were placed separately in plastic plate lined with germination test paper, this experiment consists of each concentration (8), and number of times to collect and transplant (5) [Number of times to collect data: 4, 3, 7, 14 and 21 days after sowing (DAS) in the leucaena leaves extract, and one more time at 10 DAS by moving the seedlings planted in pots (control condition/ water, 4 pots, 2 plants/ pot)], with 2 replications. Finally, measuring the growth of shoot, root, fresh weight, and dry weight of the tested seedlings, and measuring the growth of plants at 30 DAS. Means of all the treatments were calculated to inhibitory values [percent of water (control)] (Zungsontiporn & Chongrukthai, 2011).

The inhibition (%) = [1 - (average root length (etc.) of tested seedlings/ average root length (etc.) of control seedlings)] x 100 %.

Analyze the data in the Completely Randomized Design (CRD) followed by Duncan's New Multiple Range Test (DMRT).

3. Results and Discussion

3.1 Effects of the leucaena leaves extract on rice growth

The rice seedling growth decreased when treated with different concentrations of the leucaena leaves extract. The increase in leucaena concentrate was associated with the increased reduction of rice seedling growth. The effect of leucaena leaves extract on rice indicated that seedling growth was significantly varied in all the treatments, affected the root length more seriously than the shoot length of rice seedlings. Inhibition of shoot length, root length and fresh weight of rice seedlings were found the highest leucaena leaves extract at the ratio 1: 1, at 3 days were 87.78, 90.61 and 49.44%, respectively, when compared with the controlled group of plant, and the highest inhibition of dry weight at 7 days was 53.64% (Table 1, 2). According to Suresh & Rai (2012) also observed the same effects about *Eucalyptus tereticornis*, *Casuarina equisetifolia* and *L. leucocephala* in case of sorghum.

This experiment showed that the use of leucaena leaves extract had a lower inhibitory effect or promoted the growth shoot length (at 14 days) and fresh weight of rice (at 7 days). However, the rice in the pots (control conditions, moving the seedlings at 10 days after receiving the leucaena leaves extract) 30 days, it was found that the height of the rice plant was not significantly different from the control. This was in accordance with Zungsontiporn & Chongrukthai (2011), who reported that watering the plants might wash away the

Table 1. The effects of leaf extracts of *Leucaena leucocephala* on rice growth.

Leucaena: Water ratio	Percentage reduction of rice growth (% of control)						Plant height (30 DAS) (cm)
	3 DAS		7 DAS		14 DAS		
	Shoot length	Root length	Shoot length	Root length	Shoot length	Root length	
1:1	87.78 a	90.61 a	24.36 a	47.46 a	-13.08ab	29.86 a	24.59
1:2	72.36 ab	60.68 b	25.44 a	12.60bc	-9.06 ab	30.86 a	26.51
1:3	52.49 b	58.12 b	16.84ab	26.56ab	7.13 a	13.71ab	25.87
1:4	57.36 b	57.27 b	10.90ab	15.56bc	-7.84 ab	14.00ab	27.07
1:5	45.58 bc	61.92 b	16.96bc	16.96 c	-15.02 b	18.08ab	26.91
1:10	45.28 bc	61.52 b	5.39 b	28.90ab	-14.64 b	15.48ab	27.33
1:20	21.35 cd	27.02 c	4.34 b	31.44ab	-7.41 ab	3.02 b	25.98
Water (Control)	0.00 e	0.00 d	0.00 b	0.00 d	0.00 ab	0.00 b	27.30
F- test	**	**	*	**	*	*	ns
C.V.(%)	15.82	14.17	53.92	28.94	-72.27	38.85	5.10

Note: Means followed by same letter are not significantly different (* =P < 0.05, ** = P < 0.01) following DMRT, DAS: days after sowing in the leucaena leaf extract.

Table 2. The effects of leaf extracts of *Leucaena leucocephala* on rice growth (fresh and dry weight).

Leucaena: water ratio	Percentage reduction of rice growth (% of control)					
	3 DAS		7 DAS		14 DAS	
	Fresh weight	Dry weight	Fresh weight	Dry weight	Fresh weight	Dry weight
1:1	49.44 a	48.92 a	-7.14 ab	53.64 a	31.66 a	2.54 a
1:2	47.70 ab	19.69 b	-7.14 ab	38.10 ab	21.11 ab	2.94 a
1:3	39.98 abc	13.77 bc	7.14 a	28.00 abc	20.21 ab	9.22 a
1:4	26.66 abcd	11.69 bc	0.00 ab	23.64 abc	16.65 abc	5.88 a
1:5	19.05 bcd	15.62 bc	-14.28 b	23.55 abc	5.56 bc	-22.16 b
1:10	25.77 abcd	7.84 bc	-7.14 ab	16.00 bc	4.5 bc	-1.76 ab
1:20	17.14 cd	3.92 bc	-7.14 ab	13.11 bc	4.00 bc	9.12 a
Water (Control)	0.00 d	0.00 c	0.00 ab	0.00 c	0.00 c	0.00 a
F- test	**	**	*	**	**	*
C.V. (%)	28.46	28.43	-178.88	35.15	38.85	10.28

Note: Means followed by same letter are not significantly different (* = P < 0.05, ** = P < 0.01) following DMRT, DAS: days after sowing in the leucaena leaf extract.

leucaena leaves extract, so it was less toxic to the test plants. For a short time, plants were grown at the same length as the plants which without the leucaena leaves extract.

3.2 Effects of the leucaena leaves extract on wrinkle duck- beak growth

All the leucaena leaves extract inhibited shoot length and root length of wrinkle duck- beak seedlings. It was found that root length had more affected than shoot length of wrinkle duck- beak seedlings. The shoot length and root length inhibition percentage were increased with the increased concentrations of all leucaena leaves extract. The result showed that, shoot length inhibition of wrinkle duck- beak (at 3 DAS), had the most pronounced effect, found in leucaena extracts at 1: 1 to 1: 5 concentrations (ranging from 47.68 to 96.92% of the control group), while root length inhibition using the same leucaena extract group was 100%. (Table 3). According to Ishak & Sahid (2014) also observed same effects about *Leucaena leucocephala*. In case of goatweed (*Ageratum conyzoides*), coat buttons (*Tridax procumbens*) and lilac tasselflower (*Emilia sonchifolia*). After the age of 3 DAS (at 7, 14 and 21 DAS), the use of all leucaena leaves extract in wrinkle duck- beak, it was observed that the growth of the shoots was found at 1:10 and 1:20 leucaena leaves extract. So that, at 10 DAS, only the surviving seedlings of wrinkle duck - beak (at 1:10 and 1:20) were grown in control conditions pots, this experiment found that seedlings show wilt and finally die, it might be because they had no roots for absorbed water and food.

3.3 Effects of the leucaena leaves extract on mung bean growth

This study found that significant inhibitory effect was observed and it was significantly increased with the increase of leucaena concentration. Shoot growth of mung bean was found to be more affected than root growth. In this

experiment the highest growth inhibitory activity was observed at 3 DAS, mung bean shoot length at 1: 1 to 1: 4 leucaena leaves extract (79.17-88.45%), mung bean root length at 1:3 to 1:5 leucaena leaves extract (58.70-63.70%), mung bean fresh weight at 1:2 to 1:3 leucaena leaves extract (71.40-73.63%), and mung bean dry weight at 1:1 leucaena leaves extract (67.52%) (Table 4). Ahmed, Hoque, & Hossain (2008) also observed same effects about leaf litters of *L. leucocephala* in case of Falen (*Vigna unguiculata*), Chickpea (*Cicer arietinum*) and Arhor (*Cajanus cajan).* After 7 DAS, mung bean seedlings showed signs of rot and death.

4. Conclusions

In laboratory conditions, the use of leucaena leaves extract at a rate of 1:20 can inhibited the growth of wrinkle duck- beak seedlings (especially root length). The use of the leucaena extract in rice (paddy) field condition (after drainage in Nahwan Nam Tom or Wet Seeded Rice Production before sowing the germinated seeds), by spraying or watering, may require higher concentrations (Zungsontiporn & Chong-rukthai, 2011). There are environmental factors, such as water condition, which affected on decreased the concentration of leucaena leaves extract. The number of providing leucaena leaves extract should be increased, because of the age of wrinkle duck- beak had different germination levels. Seeds that are not germinated may grow after the active phase of leucaena leaves extract.

Acknowledgements

This work has been reviewed in English by Mr. Reuben H. Esteban and Ms. Tonghathai Thong-ngamkham.

Table 3. The effects of leaf extracts of *Leucaena leucocephala* on wrinkle duck- beak growth.

Leucaena: water ratio	Percentage reduction of wrinkle duck- beak growth (% of control)				
	3 DAS		7 DAS	14 DAS	21 DAS
	Shoot length	Root length	Shoot length	Shoot length	Shoot length
1:1	73.46 ab	100.00 a	100.00 a	100.00 a	100.00 a
1:2	87.66 a	100.00 a	100.00 a	100.00 a	100.00 a
1:3	70.37 ab	100.00 a	100.00 a	100.00 a	100.00 a
1:4	47.68 abc	100.00 a	100.00 a	100.00 a	100.00 a
1:5	96.92 a	100.00 a	100.00 a	100.00 a	100.00 a
1:10	12.36 bc	42.68 b	62.68 b	72.14 b	73.88 b
1:20	15.79 bc	68.30ab	39.05 c	33.00 c	46.70 c
Water (control)	0.00 c	0.00 c	0.00 d	0.00 c	0.00 d
F- test	*	**	**	**	**
C.V. (%)	50.10	19.44	5.98	8.87	6.08

Note: Means followed by same letter are not significantly different (* = P < 0.05, ** = P < 0.01) following DMRT, DAS: days after sowting in the leucaena leaf extract.

Table 4. The effects of leaf extracts of *Leucaena leucocephala* on mug bean growth.

Leucaena: water ratio	Percentage reduction of mug bean growth (% of control)							
	3 DAS		7 DAS		3 DAS		7 DAS	
	Shoot length	Root length	Shoot length	Root length	Fresh weight	Dry weight	Fresh weight	Dry weight
1:1	88.45a	53.27ab	59.02ab	67.52a	54.18a	41.67a	14.22cd	45.67a
1:2	87.12a	42.51abc	73.63 a	57.20ab	44.77a	41.06a	43.70a	28.32a
1:3	81.74a	63.70a	71.40a	58.64ab	42.07a	40.50a	31.18ab	25.85a
1:4	79.17a	59.54a	55.03ab	55.04ab	49.08a	33.33ab	29.67ab	28.38 a
1:5	72.99ab	58.70a	54.24ab	52.24abc	45.55a	32.03ab	29.57ab	34.60a
1:10	56.71b	23.75abc	52.77 ab	45.93 bc	38.01a	25.00abc	31.28ab	28.32a
1:20	30.20c	8.54bc	26.46 bc	35.08 c	45.29a	8.33cd	23.31bc	28.38a
Water (Control)	0.00d	0.00c	0.00 c	0.00 d	0.00 b	0.00 d	0.00 d	0.00 b
F-test	**	**	**	**	**	*	**	**
C.V. (%)	7.99	34.95	20.48	11.37	20.28	35.78	15.92	19.32

Note: Means followed by same letter are not significantly different (* = P < 0.05, ** = P < 0.01) following DMRT, DAS: days after sowting in the leucaena leaf extract.

References

Ahmed, R., Hoque, A. T. M. R, & Hossain, M. K. (2008). Allelopathic effects of *Leucaena leucocephala* leaf litter on some forest and agricultural crops grown in nursery. *Journal of Forestry Research, 19*, 298-302. Retrieved from http://link.springer.com/article/10.1007/s11676-008-0053-0

Bunnag, S. (1983). *Studies on mimosine and protein content in Mimosa pigra* L. *and Leucaena leucocephala* Lam. (Master's thesis, Chulalongkorn Universtiy, Bangkok, Thailand). Retrieved from http://www.pharmacy.mahidol.ac.th/medplantdatabase/pdf/1983/19830005.pdf

Chou, C. H., & Kuo, Y. L. (1986). Allelopathic research of subtropical vegetation in Taiwan III. Allelopathic exclusion of understory by *Leucaena leucocephala* (Lam.) de Wit. *Journal of Chemical Ecology, 12*(6),1431-1448. Retrieved from http://link.springer.com/article/10.1007/BF01012362

International Rice Research Institute. (2016, August 20). *Ischaemum rugosum* Salisb. Retrieved from http://www.knowledgebank.irri.org/training/fact-sheets/item/ischaemum-rugosum-salisb

Ishak, M. S., & Sahid, I. (2014). Allelopathic effects of the aqueous extract of the leaf and seed of *Leucaena leucocephala* on three selected weed species. *Proceeding of AIP Conference 1614*, 659-664. doi:10.1063/1.4895280

Kalpana, P., & Navin, M. K. (2015). Assessment of allelopathy potential of *Leucaena leucocephala* (Lam) De Vit on *Raphanus sativus* L. *International Journal of Scientific and Research Publications, 5*(1), 1-3. Retrieved from http://www.ijsrp.org/research-paper-0115/ijsrp-p3766.pdf

Kumbhar, B. A., & Patel, D. D. (2016). Allelopathic effects of different weed species on crop. *Journal of Pharmaceutical Science Bioscientific Research, 6*(6), 801-805. Retrieved from http://www.jpsbr.org/volume_6/JPSBR_Vol_6_Issue_1_htm_files/JPSBR16RS6017.pdf

Maneechote, C., Thantawil, W., Chaokongjak, S., Anantanamanee, Y., & Sathuvijan, S. (2013). Widespread and management of weeds resistant to ACCase-inhibiting herbicides. *Department of Agriculture Research Report, 2012*, 1284-1305. Retrieved from: http://www.doa.go.th/doaresearch/files/2424_2555.pdf

Parvin, R., Shapla, T. L., & Amin, M. H. A. (2011). Effects of leafs and *Leucaenea leucocephala* different tree depth soil on the allelopathy of agricultural crops. *Journal of Innovation. Development. Strategy,* 5(1), 61-69. Retrieved from http://ggfjournals.com/assets/uploads/MIN-_203_(61-69)_FINAL_(OK).pdf

Sahoo, U. K., Upadhyaya, K., & Meitei, C. B. (2007). Allelopathic effects of *Leucaena leucocephala* and *Tectona grandis* on germination and growth of maize. Retrieved from https://www.researchgate.net/publication/299171377_Allelopathic_effects_of_Leucaena_leucocephala_and_Tectona_grandis_on_gerrmnation_and_growth_of_maize

Senakusp, U., Bunnag, S., Kawisarasai, P., & Suriyajuntratong, W. (1983). Mimosine content in various varieties of Leucaena (*Leucaena Ieucocephala*). Retrieved from http://nutrition.dld.go.th/Research%20Report53-55/Research_Knowlage/RESEARCH/research_full/2526/R2603.pdf

Siaw, D. E. K. A., Kang, B. T., & Okali, D. U. U. (1991). Alley cropping with *Leucaena leucocephala* (Lam.) de Wit and *Acioa barteri* (Hook.F.). *Agroforestry Systems*, 14(3), 219-231. Retrieved from http://link.springer.com/article/10.1007/BF00115737

Suresh, K. K., & Rai, R.S.V. (2012). Studies on the allelopathy effects of some agroforestry tree crops. *International Tree Crops Journal, 4*(2-3), 109-115. Retrieved from http://www.tandfonline.com/doi/abs/10.1080/01435698.1987.9752816

Xuan, T. D., Tawata, S., & Khanh, T. D. (2013). Herbicidal activity of Mimosine and its derivatives. In A.J. Price & J.A. Kelton (Eds.), *Herbicides - Advances in Research* (Chapter 15), London, England: InTech. doi: 10.5772/55845. Retrieved from https://www.intechopen.com/books/herbicides-advances-in-research/herbicidal-activity-of-mimosine-and-its-derivatives

Zungsontiporn, S., & Chongrukthai, T. (2011). Allelopathic potential of some invasive plants in Thailand and their utilization for weed control. *Department of Agriculture Research and Development Report 2010, Volume 1*, 639-649. Retrieved from http://www.doa.go.th/research/attachment.php?aid=846