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## ALLELOPATHIC EFFECT OF *MUCUNA BRACTEATA* EXTRACT AND DIFFERENT DURATION OF DRYING ON GERMINATION AND SEEDLING OF SWEET CORN AND OKRA

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**Abstract :** This experiment was conducted at the Institute of Sustainable Agrotechnology farm and laboratory, University Malaysia Perlis, Padang Besar, Perlis, Malaysia, with an aim to evaluate the impact of *Mucuna bracteata* extract on seedling growth and germination of sweet corn and okra. Aqueous extract (dry, fresh) derived from root and shoot were used and water was kept as a control. *Mucuna bracteata* plants exposed to different drying duration were considered, namely fresh and after 1 week and 2 weeks, followed by drying at 40°C. Random distribution was followed for the experiment based on completely randomized design (CRD) with four replicates. The germination and seedling growth was significantly retarded for sweet corn and okra, treated with fresh, 1 and 2 weeks extracts when compared to control. Similarly, the number of roots as well as okra shoot length seedlings were significantly reduced by shoot extract and sweet corn seedlings' shoot length. However, shoot length of okra increased to a great extent with fresh extract from roots.

**Key words :** Allelopathic, *Mucuna bracteata*, Inhibition, Germination, Shoot length.

### 1. Introduction

When it comes to agricultural production systems, manipulation can be applied to a number of environmental conditions in order to maintain beneficial production. Nutrients and soil organic matter should be replenished, erosion prevented, beneficial physical properties of the soil maintained or improved, and pests, pathogens and weeds managed or suppressed. Future agricultural production can be enhanced further through cover crops by conferring some or the entire benefits and these are particularly useful for sustainable and low-input agrosystems [Bowman *et al.* (1998)]. A large number of legume species possess the potential to fix high quantities of nitrogen as well as other attributes such as increasing capacity of soil organic matter and cation exchange improving moisture-holding characteristics protecting land from erosion suppressing pathogens, pests and weeds minimising soil compaction

and serving as fibre, food and forage [Cherr *et al.* (2006), Dabney *et al.* (2001)]. In cropping systems, weeds can be suppressed by cover crops through competing with weeds for available resources as well as by promoting unfavourable conditions for weed establishment and germination.

Allelopathy is included in the latter mechanism, a stimulatory or inhibitory effect that can be caused by a plant on another species due to chemicals discharge into the environment [Putnam and Tang (1986)]. It has been indicated that allelopathic properties of some plants could be one of the potential reason of serious effect on growth and seedling dry weight of many plants in the rangelands and farmlands [Algandaby and Salama (2018)].

In agricultural systems, the current use of allelopathy for crop species in weed management is still low. However, allelopathic cultivars of cash crops

can be employed to expand its role [Wu *et al.* (1999)] and by preceding cash crops with cover crops that exude allelochemicals or produce residues that decompose to release allelochemicals that are phytotoxic to weeds [Batish *et al.* (2006)]. In the field of sustainable and organic cropping systems, leguminous cover crops have gained much popularity [Abdul-Baki *et al.* (2005)]. There are chances that the weed suppression caused by these cover crops could be a result of allelopathy. While seed germination of mungbean, sweet corn and okra was impeded by mungbean allelochemicals, it was induced by fresh mungbean allelochemicals [Ghassan *et al.* (2016a)]. Seed germination and seedling growth of sweet corn, mungbean and okra were found to be stimulated by aqueous extract of mungbean at vegetative stage when compared with aqueous extract at maturity and flowering stages [Ghassan *et al.* (2016b)].

In Malaysia, the most commonly employed leguminous cover crops species include *Calopogonium mucunoides*, *C. caeruleum*, *Pueraria phaseloides* (synonym for *Pueraria javanica*), *Centrosema pubescens* and *Mucuna bracteata* [Mathews and Saw (2007)]. One of the fast-growing leguminous cover crops is *Mucuna bracteata*, which can be planted in oil palm plantations to enhance soil structure and aeration, conserve soils, suppress unwanted noxious weeds and reduce rhinoceros beetles for young immature oil palm. To justify the usage as a cover crop, the study aims to determine the impact of aqueous extracts of *Mucuna bracteata* plant on sweet corn and okra seedlings growth and seed germination.

## 2. Materials and Methods

The experiment was carried out at the Institute of Sustainable Agrotechnology experimental farm and laboratory, University Malaysia Perlis, Padang Besar, Perlis, Malaysia.

### 2.1 Sample preparation

Plants were dried at 40°C for 1 and 2 weeks in the oven. Twenty grams was placed in 250 mL conical flask and added distilled water till the volume became 200 mL (giving concentration of 10%, or 100 g L<sup>-1</sup>, as recommended by Wardle *et al.* (1992)). The mixture was stirred for 10 minutes and then left for 48 hours at room temperature. Two layers of cheese cloth were used to filter the extracts followed by the use of Whatman Number 1 filter paper. Extracts were stored in the refrigerator at 5°C for use. The filtrates used in

the experiment were kept at room temperature 24 h prior from use.

### 2.2 Extracts from fresh plants

Three months post planting, *Mucuna bracteata* plants are harvested, after which these were cut into small pieces. To 200 mL of distilled water, 20 g of plants was added (making the ratio 1:10, w/v). The mixture was first stirred for about 10 min and then allowed to remain at room temperature for 48 hours. Filtration was done similar to oven dried samples.

### 2.3 Germination and seedling growth bioassay

The plants have taken in different durations, namely fresh and after 1 week and 2 weeks, followed by drying at 40°C and okra and sweet corn were used as test crops. In sterile 9 cm petri dishes that were lined with double layers of filter papers, 10 seeds were placed evenly per treatment. Then, to each petri dish, 8 mL of extract treatments was added with water as control. The experiment was carried out in dark condition to minimise light exposure for data collection. After four days of treatments application, the number of seeds germinated in each petri dish was counted, which was then expressed in terms of percentage. On the fifth day, four randomly selected seedlings were measured for number of roots/seedling, total length of sweet corn root and shoot, and okra shoot length. The formula by Singh and Chaudhary (2011) was used to determine the percentage of inhibition.

Inhibition (-) or stimulation (+) = [(Germinated seeds in extracts - Germinated seed in control)/Germinated seeds in control] × 100.

### 2.4 Statistical analysis

Completely Randomized Design (CRD) with two factors was used for bioassay experiment, which was replicated four times. The first factor was extract: Fresh, 1 weeks drying, 2 weeks drying and water used as control. The second factor was two parts: shoot and root. SAS program was used to analyse variance. Duncan's test at 0.05 probability level was employed to separate mean values.

## 3. Results

### 3.1 Germination percentage

Effect of aqueous extract of *Mucuna bracteata* on germination of okra was less in all the different duration used as compared to control (Table 1). An increase was seen in the control treatment with sweet corn but

**Table 1 :** Effect of different duration of drying of extracts on germination percentage of sweet corn and okra.

Treatments	Sweet corn		Okra	
	Germination (%)	Inhibition (%)	Germination (%)	Inhibition (%)
Control	72.5 a		90 a	
Fresh	63.75 a	- 12.06	82.50 b	- 8.33
Drying (1 week)	68.75 a	- 5.17	56.25 c	- 37.5
Drying (2 weeks)	68.75 a	- 5.17	63.75 c	- 29.16

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ )

different extracts showed no significance. In contrast, 1 weeks drying produced less germination, *i.e.* 56.25% for okra and in the case of 2 weeks drying, it was insignificant.

For extract of 1 week and 2 weeks drying plants were significantly inhibited to germination of okra 37.5% and 29.16% respectively, while extracts of fresh inhibited to germination of okra 8.33% (Table 1).

When compared with the fresh extract, the dry plant extracts were more phytotoxic, which could be because of accumulation and synthesis of more potential phytochemicals in plants post drying [Riti (2012)]. In the same context, dry aqueous extracts of sunflower as reported by Zahir and Majeed (2014) were more phytotoxic when compared to fresh aqueous extracts on germination of maize and wheat. Similarly, Riti (2012) observed fresh extract of *Hyptis suaveolens* leaves to be better when compared to extract of dry leaves with regards to germination of *Parthenium hysterophorus* L.

The seed germination in sweet corn and okra was not affected by the extracts of root and shoot (Table 2).

**Table 2 :** Effect of different plant parts on germination percentage of sweet corn and okra.

Treatments	Sweet corn	Okra
	Germination (%)	Germination (%)
Root	65.62 a	73.12 a
Shoot	71.25 a	73.12 a

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

Table 3 showed the control treatment for okra seed germination, with the highest average of 90%. However, extract of 1 week drying with root gave less value of 45%. But, there were no significant effect among treatments in seed germination for sweet corn.

The extract of 2 weeks in shoot part was significantly inhibitory to germination of okra 41.66% (Table 3). Results from different localities and different allelopathic plants were reported to affect germination. May and Ash (1990) reported less suppressive effect of leachate from intact fresh leaves of *Eucalyptus* spp than dry foliage on tested plants. For extract of 4 weeks drying at flowering stage gave lowest value for seed germination (54%) compared to fresh extracts at vegetative and flowering stages and control treatment that gave highest values in seed germination (87.33%, 82.66% and 80% respectively), probably due to higher metabolic activities in flowering stage resulting in accumulation of potential phytochemicals. Contrary to the results in okra and similarly to the results in sweet corn, Assaeed and Al-Doss (1997) noted that the inhibition effect of fresh leaves was less than dry leaves.

The results of this study showed dry plant extracts to be more phytotoxic than with the fresh extract. This could be because of accumulation and synthesis of more potential phytochemicals in plants post drying. Also, the effect varies with concentration, type of the extract (fresh or dry), plant age and type of the material being used. Seed characteristics like size and coat permeability were also reported to cause an impact on the uptake. It was reported that seed characteristics such as seed size and seed coat permeability can also affect the uptake and effects of allele-chemicals in seeds and interference of the allele-chemicals varied accordingly [Riti (2012)].

### 3.2 Number of roots and total root length

The presence of stimulatory substances was shown by the extract of 1 and 2 weeks drying denoted by increase in the number of root for sweet corn (Table 4). In contrast, considerable inhibition was seen the extracts of 1 and 2 weeks for the number of okra roots (5.86 and 7.50 root/seedling, respectively), total root

**Table 3 :** Effect of interaction between different duration of drying of extracts and different parts on germination percentage of sweet corn and okra.

Treatments		Sweet corn		Okra	
		Germination (%)	Inhibition (%)	Germination (%)	Inhibition (%)
	Control	72.5 a		90 a	
Root	Fresh	60 a	- 16.55	82.50 a	- 8.33
	Drying (1 week)	65 a	- 10.34	45.00 c	- 50
	Drying (2weeks)	65 a	- 10.34	75.00 ab	- 16.66
Shoot	Fresh	67.5 a	- 6.89	82.50 a	- 8.33
	Drying (1 week)	72.5 a	0	67.50 b	- 25
	Drying (2weeks)	72.5 a	0	52.50 c	-41.66

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

length of sweet corn (2.85 and 2.88 cm, respectively) and okra total root length (2.07 and 2.25 cm, respectively). The presence of inhibitory level of phytochemicals was shown by extract of 1 and 2 weeks drying because of decreased number and total root length for sweet corn and okra. However, the variable effect might be because of the difference in genetics and development of resistance to extract in the case of number of roots of sweet corn. The inhibitory nature of 1 and 2 weeks dried extracts could also be the reason. The dryness of material and freshness could have an impact on the phytochemical concentration. It was clear that the inhibitory nature was more prevalent with the dried extract than with fresh and also dried extracts being more toxic than fresh [Fazal *et al.* (2013)]. Our findings are in line with many other similar studies that have presented differential toxicity for aqueous extracts taken from other plants [Hamayun *et al.* (2005) and Pereira *et al.* (2008)].

According to Table 5, the lowest total root length of 2.33 cm was associated with okra treated with shoot extract. However, there was no significant effect between shoot and root extracts regarding sweet corn number of roots and total root length as well as okra

number of roots. Inhibition was seen in the total root length of okra seedlings that were treated with the prepared aqueous extract through *Mucuna bracteata* shoot. Rahman (1998) found similar results in the effect of aqueous extract made from inflorescence, stem and leaves of *Barthenium hysterophorus* L. on the radicle and plumule growth of *Cassia sophera* L. However, in this study, the total root length of okra was not affected by the aqueous extracts derived from the root of *Mucuna bracteata*. This can be attributed to the presence of low-concentration allelochemicals in the aqueous extract of the root. The findings of Miller (1996) agreed with this, where water extract of top growth of *Medicago sativa* L. was seen to create more allelopathic effect on seedlings when compared with extracts from the roots. Also, according to Mahmoodzadeh and Mahmoodzadeh (2013), higher inhibition was seen with the radicle growth of germinating *Triticum aestivum* seedlings that were treated with aqueous extract made from *Cynodon dactylon* fresh and dried shoot when compared with the aqueous extract made from *Cynodon dactylon* fresh and dried root.

According to Table 6, the number of roots was the

**Table 4 :** Effect of different duration of drying of extracts on number of roots sweet corn and okra.

Treatments	Sweet corn		Okra	
	Number of roots/ seedling	Total root length/ seedling (cm)	Number of roots/ seedling	Total root length/ seedling (cm)
Control	5.62 b	4.85 a	14.12 a	3.96 a
Fresh	5.95 b	2.93 b	12.65 a	2.81 b
Drying (1 week)	7.04 a	2.85 b	5.86 b	2.07 c
Drying (2 weeks)	6.98 a	2.88 b	7.50 b	2.25 c

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

**Table 5 :** Effect of extract from different parts of *Mucuna bracteata* on number of roots of sweet corn and okra.

Treatments	Sweet corn		Okra	
	Number of roots/seedling	Total root length/seedling (cm)	Number of roots/seedling	Total root length/seedling (cm)
Root	6.43 a	3.67 a	10.57 a	3.28 a
Shoot	6.37 a	3.09 a	9.69 a	2.33 b

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

**Table 6 :** Effect of interaction between different duration of drying of extracts and different parts on number of roots of sweet corn and okra.

Treatments		Sweet corn		Okra	
		Number of roots/seedling	Total root length/seedling (cm)	Number of roots/seedling	Total root length/seedling (cm)
	Control	5.62 c	4.85 a	14.12ab	3.96 a
Root	Fresh	5.90 bc	3.19 b	14.50 a	3.92 a
	Drying(1 week)	7.03 a	3.18 b	5.00 d	2.34bc
	Drying (2weeks)	7.16 a	3.43 ab	8.01 cd	2.76 c
Shoot	Fresh	6.00 bc	2.67 b	10.80 bc	1.70 c
	Drying(1 week)	7.04 a	2.52 b	6.72 d	1.79 c
	Drying(2 weeks)	6.80 ab	2.32 b	7.12 d	1.87 c

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

highest for sweet corn (7.16 roots/seedling) for seedlings treated with extract of 2 weeks of root, while the lowest was with the control (5.62 roots/seedling). The highest value for okra (14.50 roots/seedling) was achieved with fresh extract of root, whereas, significantly lowest (14.50 roots/seedling) was achieved with extract of 1 week of root. The total root length was highest for the seedlings under control treatment for sweet corn and okra (4.85 and 3.96 cm, respectively). The reduction in the number of roots for dry extracts can be attributed to dry extracts of *Mucuna bracteata*, which could have produced more toxic compounds and there was a continuous contact of the roots with the extracts. Since seedling root growth reacts to allele-chemicals, cell division and cell elongation in the root apical meristems could occur due to longer contact with the extract [Zhang and Fu (2009)].

The highest average of root numbers was with okra, while the lowest with sweet corn. These could be a result of crops differential behaviour responding to water extract. Different crops have been seen to respond in different ways to the same type of allele-chemicals [Pukclai and Kato-Noguchi (2012)].

As seen in Table 7, a considerable increase in shoot length of sweet corn and shoot length of okra by 3.71 and 5.13 cm, respectively was observed in control treatment. The sweet corn shoot length was decreased significantly to 2.50 cm with the extract of 2 weeks drying, and okra's shoot length decreased significantly to 2.12 cm with 1 week drying. The reduced growth could be attributed to the impact of allelopathic compounds on cell elongation, cell division, cell wall structure and membrane permeability [Zhang and Mu (2008)]. According to Jafariehyazdi and Javidfar (2011), brassica extract presented more reducing effects on shoot length of sunflower shoot length.

As seen in Table 8, a significant increase was observed in shoot length of sweet corn and okra that were treated with extract from root (3.38 and 3.87 cm, respectively). By contrast, shoot length of sweet corn and okra reached 2.81 and 2.85 cm, respectively, which were treated with shoot extract. The results demonstrated that shoot of *Mucuna bracteata* is subject to considerably greater allelopathic effect than the plant root. This suggested that the applied shoot extracts also included growth inhibitory substances that were enough to suppress shoot growth for these

seedlings more than root extract. The same pattern as seen for the number of roots and total root length was followed by variation in the treated shoot length of seedlings. During most parts of the experiment, seedlings with shortest root length were seen for the shoot aqueous extract. The findings of Kadioglu *et al.* (2005) supported the results as well. Inhibition in the germination rate as well as final germination was reported for chickpea (*Cicer arietinum*), lentil (*Lens culinaris*) and wheat (*Triticum aestivum*) with various plant part extracts of different broad and narrow leaf weeds. Our findings agreed with those of Tanveer *et al.* (2010), who concluded a greater inhibitory effect possessed by leaf extract compared to other extracts through examination of the allelopathic effect of stem, root, leaf and fruit water extracts as well as infested soil of *Euphorbia helioscopia* on the seedling growth and seed germination of chickpea, wheat and lentil. Similarly, Dongre and Singh (2007) reported that the growth of *Triticum aestivum* was considerably inhibited by leaf leachates of *Amaranthus viridis*, *Polygonum plebeium* and *Parthenium hysteroporus*.

From Table 9, the control treatment produced substantial increase in shoot length of sweet corn to 3.71 cm, while fresh extract from root resulted in a considerable increase in shoot length of okra seedlings to 5.23 cm, when compared with extracts from other treatment combination. This present study suggested that phytochemicals could be present in fresh aqueous extract of *Mucuna bracteata*, which could also perform stimulatory function. These chemicals stimulatory functions could be clearly seen with the substantial enhancement of growth parameters in okra (total root length and number of root). These results were in line with the published reports regarding sunflower allelopathy against maize and wheat [Zahir and Majeed (2014)] reported a similar growth promoting effect on wheat seedlings, where the phytochemical source was the application of senna mulching.

Seedling growth and germination of sweet corn and okra were seen to get affected by water extract of *Mucuna bracteata* (Tables 1, 2, 4, 5, 7 and 8). These could be as a result of crops differential behaviour in response to water extract. The findings of Katoch *et al.* (2012) supported these results, who reported differential response shown by wheat, maize and rice to water extracts of *Eupatorium adenophorum* and *Ageratum conyzoides*, where germination and seedling

**Table 7 :** Effect of different duration of drying of extracts on shoot length of sweet corn and okra.

Treatments	Sweet corn	Okra
	Shoot length/ seedling (cm)	Shoot length/ seedling (cm)
Control	3.71 a	5.13 a
Fresh	3.26 ab	3.81 b
Drying (1 week)	2.90 bc	2.12 c
Drying (2 weeks)	2.50 c	2.16c

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

**Table 8 :** Effect of extract of different parts on shoot length of sweet corn and shoot length of okra.

Treatments	Sweet corn	Okra
	Shoot length/ seedling (cm)	Shoot length/ seedling (cm)
Root	3.38 a	3.87 a
Shoot	2.81 b	2.85 b

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

**Table 9 :** Effect of interaction between different duration of drying extracts and different partson shoot length of sweet corn and okra.

Treatments		Sweet corn	Okra
		Shoot length/ seedling (cm)	Shoot length/ seedling (cm)
	Control	3.71 a	5.13 a
Root	Fresh	3.50 a	5.23 a
	Drying (1 week)	3.44 ab	2.33 b
	Drying (2weeks)	2.86 abc	2.40 b
Shoot	Fresh	3.037 abc	2.39 b
	Drying (1 week)	2.36 bc	1.91 b
	Drying (2 weeks)	2.15 c	1.99 b

\* Different alphabets in the same column show significant difference using Duncan's Multiple Range test ( $P \leq 0.05$ ).

growth of wheat and rice were found to be great compared to maize. Similarly, Chatiyanon *et al.* (2012) examined the water extract of *Hyptis suaveolens* against *Mimosa invisa* and *Pennisetum setosum* seedlings, and reported that susceptibility was more in the germination and seedling growth of *P. setosum* than with *M. invisa*. Ali *et al.* (2014) also found *Vigna sativa* to differently affect germination percentage, germination index, shoot length and seedling dry weight

of mungbean and mashbean.

## 5. Conclusion

As observed from the results, phytochemicals, which were derived from extracts of fresh, 1 and 2 weeks drying had an impact on the germination and seedling growth of okra and sweet corn. Most reduction was observed with germination and seedling growth of sweet corn and okra for extracts of 1 and 2 weeks post drying, except for the number of roots of sweet corn. Compared to root extract, shoot extracts showed greater effect. The extracts of *Mucuna bracteata* had water soluble inhibitory and promotory substances. The soluble substances possess the potential to greatly impact germination and seedling growth of sweet corn and okra. *Mucuna bracteata* fresh biomass could be employed in the vegetable field as cover crop, which could also help reduce germination and seedling growth of weeds. Further studies, however, are required to identify the exact allele-chemicals, which inhibit the seedling growth of okra and sweet corn by *Mucuna bracteata*.

## References

- Abdul-Baki, A.A., W. Klassen, H.H. Bryan, M. Codallo, B. Hima, Q.R. Wang, Y. Li, Y.C., Lu and Z. Handoo (2005). A biologically-based system for winter production of fresh-market tomatoes in South Florida. *Proc. Fla. State Hort. Soc.*, **118**, 153-159.
- Algandaby, M.M. and M. Salama (2018). Management of the noxious weed; *Medicago polymorpha* L. via allelopathy of some medicinal plants from Taif region, Saudi Arabia. *Saudi Journal of Biological Sciences*, **25**(7), 1339-1347.
- Ali, Z., Ehsanullah, T. Tabassum, T. Abbas and T. Rasool (2014). Influence of water soluble phenolics of *Vicia sativa* L. on germination and seedling growth of pulse crops. *Sci. Agri.*, **8**(3), 148-151.
- Assaeed, A. M. and A. A. Al-Doss (1997). Allelopathic effects of *Rhazya stricta* on seed germination of some range plant species. *Annals of Agricultural Sciences, Ain Shams Univ., Cairo*, **42**(1), 159-167.
- Batish, D.R., H.P. Singh, R.K. Kohli and G.P. Dawra (2006). Potential of allelopathy and allelochemicals for weed management. In: H.P. Singh, D. R. Batish, and R. K. Kohli (Eds.). *Handbook of sustainable weed management*. Food Products Press, NY.
- Bowman, G, C. Shirley and C. Cramer (1998). *Managing cover crops profitably*. 2nd ed. Sustainable Agriculture Network, Beltsville, Md.
- Chatiyanon, B., T. Tanee, C. Talubmook and C. Wongwattana (2012). Effect of *Hyptis suaveolens* Poit leaf extracts on seed germination and seedling growth of *Pennisetum setosum* (Swartz.) L.C. Rich and *Mimosa invisa* Mart. *Agri J.*, **7**, 17-20.
- Cherr, C.M., J.M.S. Scholberg and R. McSorley (2006). Green manure approaches to crop production: A synthesis. *Agron. J.*, **98**, 302-319.
- Dabney, S.M., J.A. Delgado and D. W. Reeves (2001). Using winter cover crops to improve soil and water quality. *Commun. Soil Sci. Plant Anal.*, **32**, 1221-1250.
- Dongre, P.N. and A.K. Singh (2007). Inhibition effects of weeds on growth of wheat seedlings. *Allelopathy Journal*, **20**(2), 387-394.
- Fazal, H., A. Razzaq, G. Ali and A. Rashid (2013). Allelopathic potential of *Desmostachya bipinnata* (L.) P. Beauv. on wheat varieties (Ghaznavi and Tatar). *Scholarly Journal of Agricultural Science*, **3**(8), 313-316.
- Ghassan, J.Z., W. Zakaria, A.R. Shaari and C. H. Mohammad (2016a). Allelopathic effect of mungbean extract on germination and seedling growth of mungbean, sweet corn and okra. *Indian Research Journal of Pharmacy and Science*, **3**(2), 563-569.
- Ghassan, J.Z., W. Zakaria, A.R. Shaari and C. H. Mohammad. (2016b). Allelopathic effect of aqueous extract of *Vigna radiata* at three growth stages on seed germination and seedling growth of *Vigna radiata*, *Zea mays* and *Abelmoschus esculentus*. *International Journal of Scientific & Engineering Research*, **7**(9), 369-379.
- Hamayun, M., F. Hussain, S. Afzal and N. Ahmad (2005). Allelopathic effects of *Cyperus rotundus* and *Echinochloa crusgalli* on seed germination and plumule and radicle growth in maize (*Zea mays*). *Pak. J. Weed Sci. Res.*, **11**, 81-84.
- Hussain, S., S. Siddiqui, S. Khalid, A. Jamal, A. Qayyum and Z. Ahmad (2007). Allelopathic potential of senna (*Cassia angustifolia* Vahl.) on germination and seedling characters of some major cereal crops and their associated grassy weeds. *Pak. J. Bot.*, **39**(4), 1145-1153.
- Jafariehyazdi, E. and F. Javidfar (2011). Comparison of allelopathic effects of some brassica species in two growth stages on germination and growth of sunflower. *Plant Soil Environ.*, **57**(2), 52-56.
- Kadioglue, I., Y. Yanar and U. Asav (2005). Allelopathic effects of weed leachates against seed germination of some plants. *J. Environ. Biol.*, **26**(2), 169-173.
- Katoch, R., A. Singh and N. Thakur (2012). Allelopathic influence of dominant weeds of North-Western Himalayan region on common cereal crops. *Intl. J. Environ. Sci.*, **3**(1), 84-97.



- Mahmoodzadeh, H. and M. Mahmoodzadeh (2013). Allelopathic effects of *Cynodon dactylon* L. on germination and growth of *Triticum aestivum*. *Annals of Biological Research*, **5**(1), 118-123.
- Mathews, J. and E.K. Saw (2007). IOI's experiences with establishing *Mucuna bracteata* on soil derived. In: *Mucuna Bracteata*, A Cover Crop Living Green Manure. Goh, K.J. and S. B. Chiu (eds.). Agricultural Crop Trust (ACT), Petaling Jaya.
- May, F.E. and J.E. Ash (1990). An assessment of the allelopathic potential of Eucalyptus. *Australian Journal of Botany*, **38**, 245-254.
- Miller, D.A. (1996). Allelopathy in forage crop system. *Agron J.*, **88**, 854-859.
- Pereira, B.F., A.F. Sbrissia and B.M. Serrat (2008). Intra-specific allelopathy of leaves and roots aqueous extracts on germination and early seedling growth of two alfalfa materials: Crioulo and improve. *Ciencia Rural*, **38**, 561-564.
- Pukclai, P. and H. Kato-Noguchi (2012). Allelopathic potential of *Tinospora tuberculata* Beumee on twelve test plant species. *J Plant Bio Res.*, **1**, 19-28.
- Putnam, A.R. and C.S. Tang (1986). *The science of allelopathy*. Wiley, N.Y.
- Rahman, A. (1998). Allelopathic potential of *Parthenium hysterophorus* linn. on germination, growth and dry matter production in *Cassia sophera* linn. *Bionature*, **18**(1), 17-20.
- Riti, T.K. (2012). Phytotoxic Potential of Fresh Leaf Leachates and Dry Leaf Extracts of *Hyptis suaveolens* to Control *Parthenium hysterophorus* L. International Conference on Chemical Processes and Environmental issues (ICCEEI'2012) July 15-16 Singapore..
- Singh, A.P. and B.R. Chaudhary (2011). Allelopathic potential of algae weed *Pithophora aedogonia* (Mont.) on the germination and seedling growth of *Oryza sativa* L. *Botany Research International*, **4**(2), 36-40.
- Tanveer, A., A. Rehman, M.M. Javaid, R.N. Abbass, M. Sibtain, A.U.H. Ahmad, M.S. Ibin-I-Zamir, K.M. Chaudhary and A. Aziz (2010). Allelopathic potential of *Euphorbia helioscopia* L. against wheat (*Triticum aestivum* L.), chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medic.). *Turkish Journal of Agriculture and Forestry*, **34**, 75-81
- Wardle, D.A., K.S. Nicholson and M. Ahmed (1992). Comparison of osmotic and allelopathic effects of grass leaf extract on grass seed germination and radicle elongation. *Plant and Soil*, **140**(2), 315-319.
- Wu, H., J. Pratley, D. Lemerle and T. Haig (1999). Crop cultivars with allelopathic capability. *Weed Res.*, **39**, 171-180.
- Zahir, M. and A. Majeed (2014). Allelopathic effect of aqueous extracts of sunflower on wheat (*Triticum aestivum* L.) and maize (*Zea mays* L.). *Pak. J. Bot.*, **46**(5), 1715-1718.
- Zhang, Y. and X. Mu (2008). Allelopathic effects of *Amaranthus retroflexus* L. and its risk assessment. *Acta Botanica Boreali-Occidentalia Sinica*, **104**, 87-91.
- Zhang, C. and S. Fu (2009). Allelopathic effects of eucalyptus and the establishment of mixed stands of eucalyptus and native species. *Forest Ecology and Management*, **258**, 1391-1396.