MORPHOLOGICAL AND PHYSIOLOGICAL RESPONSE OF MAIZE TO SOME ALLELOPATHIC PLANT EXTRACTS

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ABSTRACT

An experiment was conducted to investigate the allelopathic response of different plant extracts on the morpho-physiological traits of maize crop. The experiment was carried out in a completely randomized design having three repetitions. Water extracts of ten different plants viz., neem (Azadirachta indica L.), eucalyptus (Eucalyptus camaldulensis L.), tobacco (Nicotiana tobacum L.), Indian lilac (Melia azadirach L.), acacia (Acacia nilotica L.), poplar (Populous deltoids L.), sunflower (Helianthus annuus L.), jaman (Syzygium cumini L.) and karir (Capparis decidua L.) were used in this study along with distilled water (control). Tobacco and sunflower extracts were prepared by grinding the mature harvested dry leaves while other plant extracts were prepared by grinding the mature harvested dry stem peel and their 20% concentrated extracts were obtained. The extracts were applied after preparation of 72 hours and were used as per requirement of plants till 30 days. The data recorded after 15 and 30 days after sowing exhibited that all the studied parameters were negatively influenced by the application of neem, eucalyptus and tobacco aqueous extracts which means that maize plants showed poor morpho-physiological growth response against these solutions. Least allelopathic response was noted by the application of jaman and karir extract after control. Further studies are suggested to isolate the allelopathins from the neem and eucalyptus further studies and their use as herbicides for the sustainability of agroeosystems.

Keywords: Allelopathic response, *Azadirachta indica,* phytotoxicity, plant extracts, *Zea mays.*

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INTRODUCTION

Maize *(Zea mays* L.) crop has the capacity to produce a large quantity of grains per unit land area and having two crops usually in a year i.e. 1st in spring and 2nd in summer season. Maize yield is marginal rather poor in most parts of the country due to cultivation of open pollinated cultivars along with several other biotic and abiotic stresses including weed infestation, nutrients deficiency, drought etc. Nazir *et al.* (2010) suggested that yield could be increased through sowing of high yielding hybrids with their suitable adaptability in the different regions. Allelopathy can also be considered among the yield limiting factors because several plants produce various type of allelochemicals which can suppress other plants (Zimdahl, 2007; Khan *et al.,* 2009). For example, sunflower releases certain chemicals including flavonoids, phenolic and terpenoids compounds (Macias *et al*., 2004). Vaithiyanathan *et al.* (2014) reported that neem plant also accumulates allelochemicals which inhibit the germination of certain plants. These chemicals are released into the rhizosphere (Ashrafi *et al.,* 2008). The inhibitory and stimulatory action of these allelochemicals is dependent on chemical nature and concentration of chemical compounds (Mahmood *et al.,* 2013). Keeping this in view, a research experiment was designed to evaluate the allelopathic interactions of certain plants and trees with maize. The key objective was to find out the dynamics of the growth behaviors in terms of its dry matter accumulation and response of other physiological parameters in response to application of different plant extracts representing the stay-green (SG) type.

MATERIALS AND METHODS

The experiment was conducted at the Department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, Khyber Pakhtunkhwa province, Pakistan. The vegetative stalks of the of maize open pollinated variety 'Azam white' was acquired from Agricultural Research Institute (ARI), Dera Ismail Khan. The leaves of the plants and chopped stems were collected from different locations around the Gomal University. The experiment was performed in clay pots in a completely randomized design. Ten different treatments were used including T_1 = Neem (*Azadirachta indica* L.), T_2 = Eucalyptus (*Eucalyptus camaldulensis* L.), T_3 = Tobacco (*Nicotiana tobacum* L.), T_4 = Indian lilac (*Melia azedarach* L.), T_5 = Acacia (*Acacia nilotica* L.), T_6 = Poplar (*Populous deltoids* L.), T_7 = Sunflower (*Helianthus annuus* L.), T_8 = Jaman *(Syzygium cumini* L.), T_9 = Karir (*Capparis decidua* L.) and T_{10} = Control (tap water).

The plant extracts of sunflower and tobacco leaves were prepared from collected mature leaves. The leaves were dried in shade and ground. The stem peel of neem, eucalyptus, Indian lilac, acacia, poplar, jaman and karir were collected, sundried and grounded. By taking 400 g of powder with 2 L of water, the extract was prepared. Then powder of leaves and stem peel were dissolved in distilled water. These extracts were stored in plastic containers for future use. The extracts were applied at sowing and after 72 hours interval. Data were recorded on various physiological and agronomic attributes and were subjected to analysis of variance technique (Steel *et al*., 1997). Leaf area of maize was recorded as outlined by Musa *et al.* (2016). The treatment means were separated through Tukey's HSD Test (Black, 2011) Mean Separation Test by using "Statistix 8.1" computer software.

RESULTS AND DISCUSSION

Germination %

Germination is the most crucial stage in the plant's lifecycle and it is influenced by several environmental factors. The results presented in Table-1 show the maximum inhibition (33.16%) in the germination by neem extract which was followed by eucalyptus with 41.50% germination. Minimum inhibition in the germination was noted by the application of karir with 100% germination. Vaithiyanathan *et al.* (2014) also noted that the germination of *Abelmoschus esculentus* L. was adversely affected by aqueous extract of neem (Table-1). Roth *et al.* (2000), Khan *et al.* (2007) and Deka *et al*. (2011) also concluded that aqueous extract of neem had inhibitory effects on germination of various crop plants. Carvalho *et al*. (2015) reported that eucalyptus species have inhibitory effects on the germination of various plants. Neelamegam and Dhanusha (2016) found that germination and seedling growth of paddy was inhibited by neem leaf extract. It is recognized as biological insecticide due to chemicals present in its leaves, seeds and bark. It consists of alkaloids such as nimbin, nimbidin, nimbidol, gedunin, sodium nimbinate, quercetin, salannin and azadirachtin (Sankaram, 1987). Ashrafi *et al.* (2009) also concluded that the n-hexanesoluble, acetone-soluble and water-soluble fractions obtained from the acetone extract of *A. indica* shoots inhibited the germination and growth of roots and shoots of six test plant species. The inhibitory activity of the water-soluble fraction has been the greatest in their studies.

Root-shoot ratio

The results about root-shoot ratio are also presented in Table-1. Maximum reduction in root-shoot ratio (0.20) was shown by neem which was followed by eucalyptus having root-shoot ratio of 0.23. The least adverse effect was shown by karir with 0.70 root-shoot ratio 15 days after sowing. Root-shoot ratio recorded 30 days after sowing showed maximum reduction by the application of neem (0.17), followed by eucalyptus (0.20). Minimum reduction in root-shoot ratio (0.76) was noted in karir extract (Table-1). Deka *et al*. (2011) presented similar inhibitory results of neem on growth of several crop plants including maize, rice and wheat. Kasarkar and Barge (2016) also found that neem extract inhibited the root and shoot growth of many agricultural crops. Carvalho *et al*. (2015) noticed that root-shoot ratio of some plants was found sensitive to aqueous extract of eucalyptus, in their findings.

Fresh weight of plant (g)

The data for the fresh weight of plant are also shown in Table-1. Fresh weight of maize plants, 15 days after sowing was significantly influenced by the application of different extracts. Maximum reduction in fresh weight (0.40 g) was noted by the application of neem extract which was statistically at par with the application of eucalyptus (0.64 g). It was followed by tobacco extract with a fresh weight of 0.80 g. Minimum reduction in fresh weight of plant (1.88 g) was recorded by the application of karir extract. Similar reduction in fresh weight of maize plants was noted 30 days after by the application of different plant extracts. Maximum reduction in fresh weight (0.94 g) was obtained by the application of neem extract which was at par statistically with the application of eucalyptus (1.30 g) and followed by tobacco extract with plant fresh weight of 2.52 g. Minimum inhibition in fresh plant weight (9.48 g) was found by the application of karir extract (Table-1). Earlier Vaithiyanathan *et al.* (2014) reported that weight of several crop plants was inhibited by the application of neem extract. Yazdani and Bagheri (2011) also reported that tobacco plant had reduced fresh weight of soybean.

Dry weight (g)

The results pertaining to dry weight of plants are presented in Table-1. Analysis of the data revealed that maximum reduction in dry weight of plants was found by the application of neem extract (0.13 g). It was followed by the application of eucalyptus and tobacco extracts having dry weight of 0.18 and 0.23 g, respectively. Least reduction in dry weight was found by the application of karir extract (0.66 g), 15 days after sowing. Similarly dry weight of plants 30 days after sowing exhibited the highest reduction (0.29 g) by the application of neem extract, followed by the application of eucalyptus extract (0.51 g). Minimum reduction in dry weight of maize plants was noted by the application of jaman extract (2.08 g [Table-1]. Similar results were reported by Yazdani and Bagheri (2011), Vaithiyanathan *et al.* (2014) and Carvalho *et al*. (2015), Kasarkar and Barge (2016) that aqueous extract of neem, tobacco and eucalyptus decreased dry matter accumulation of various crop plants.

Root length (cm)

The results about root length (cm) are presented in Table-1. The data showed maximum reduction in root length (3.75 cm) by the application of neem extract, followed by eucalyptus extract showing root length of 6.80 cm. The least adverse effect was shown by karir extract with 12.50 cm root length 15 days after sowing. Root length measured 30 days after sowing revealed that maximum reduction (5.55 cm) was scored by neem extract. It was followed by eucalyptus (8.50 cm) root length. Minimum reduced root length of 13.30 cm was obtained by applying karir extract (Table-1). These results are in line with Vaithiyanathan *et al.* (2014) who reported that root length of *Abelmoschus esculentus* L was adversely affected by aqueous extract of neem. Carvalho *et al*. (2015) also reported that root length was inhibited by aqueous extract of eucalyptus. Likewise, inhibitory efficacy of some forest species has also been reported by Hassan *et al.* (2008).

Plant height (cm)

The data showed that the maximum adverse effect on plant height (12.12 cm) was recorded by the application of neem extract, which was followed by eucalyptus showing plant height of 14.70 cm (Table-2). The least adverse effect was shown by karir with 34.11 cm plant height. Similar trend was noted 30 days after sowing wherein maximum reduction in plant height (20.24 cm) was scored by neem extract, which was followed by eucalyptus having 24.31 cm plant height. Minimum reduction in plant height (52.80 cm) was caused by karir extract after control. Similar results were reported by Kasarkar and Barge (2016) in which plant height of maize was markedly reduced by the application of neem extract.

Number of leaves (plant^{-1})

The results indicated that neem extract had the maximum adverse influence on maize number of leaves (2.83 plant^{-1}), followed by eucalyptus (3.35 plant^{-1}) 15 days after sowing (Table-2). The least adverse effect was caused by karir extract with 4.86 number of leaves (plant^{-1}). Number of leaves (plant^{-1}) recorded 30 days after sowing showed maximum reduction (3.00) by the application of neem and eucalyptus extracts. Maximum (7.50) number of leaves (plant^{-1}) was noted in karir extract treatment. These results are in the agreement with Ologundudu *et al.* (2016) in which they found that neem extract significantly reduced the number of leaves in rice plant. Zhang *et al*. (2002) also noted that neem seed extract reduced the number of leaves in several crops which resulted in the lower yield.

Leaf area index (cm^2)

The results regarding leaf area index are also presented in Table-2. The data showed significant influence of plant extracts on leaf area index of maize 15 days after sowing. Maximum reduction

(11.90) in leaf area was found by the application of neem extract, followed by the application of eucalyptus extract (18.20). The least reduction (61.11) in leaf area was noted by the application of karir extract. Leaf area measured 30 days after sowing showed maximum reduction (34.96) by neem extract, which was followed by eucalyptus (41.57). Minimum reduction in leaf area (137.20) was recorded in karir extract treatment. Zhang *et al*. (2002) and Ologundudu *et al.* (2016) showed that leaf area of various crops was reduced by the application of neem extract, which resulted in poor vegetative growth and ultimately lower yield.

Chlorophyll contents (µg cm^{-2})

The data presented in Table-2 elucidated that neem extract caused maximum adverse influence on chlorophyll contents of maize (12 µg cm^{-2}). It was followed by eucalyptus (14.70 µg cm^{-2}). The least adverse effect was shown by karir extract (36.55 µg cm^{-2}) 15 days after sowing. Chlorophyll contents observed 30 days after sowing revealed maximum reduction in chlorophyll contents by the application of neem (15.05 µg cm^{-2}), followed by eucalyptus (17.70 µg cm^{-2}). Maximum chlorophyll content (36.55 µg cm^{-2}) was noted by the application of karir extract (Table-2). Vaithiyanathan *et al.* (2014) and Yazdani and Bagheri (2011) also reported similar results wherein chlorophyll contents of various plants were influenced by the application of neem and tobacco extracts.

CONCLUSIONS

The data recorded in this experiments exhibit the variable phytotoxicity among the test species. The inhibitory effect on different parameters of maize reveals the allelpathy of test species as neem, eucalyptus, tobacco, Indian lilac, acacia, poplar, sunflower, jaman and karir; in the descending order. Hence, the allelopathy of neem and eucalyptus is suggested to be exploited in the sustainable management of weeds after due studies on the selectivity of allelopathins among the crops and weeds. Further studies are also suggested to isolate allelopathins involved in the suppression of the growth of maize.

Table-1. Allelopathic influence of various plant extracts on germination (%), root-shoot ratio, fresh weight of plant (g), dry weight of plant (g) and root length (cm) of maize.

Treatments	Germiation %	Root-shoot ratio		Fresh weight (g)		Dry weight (g)		Root length (cm)	
		After 15 days	After 30 days	After 15 days	After 30 days	After 15 days	After 30 days	After 15 days	After 30 days
Neem	33.2 d	0.20 c	0.17 c	0.40 f	3.75 c	0.13 f	0.29 f	3.75 c	5.55 f
Eucalyptus	41.5 d	0.23 c	0.20 c	0.64 ef	6.80 bc	0.18 ef	0.51 ef	6.80 bc	8.50 e
Tobacco	50.0 cd	0.27 bc	0.22 c	0.80 e	7.50 bc	0.23 ef	0.59 def	7.50 bc	9.10 de
Indian lilac	66.6 bc	0.29 bc	0.25 c	1.14 d	8.05 abc	0.28 def	1.03 c-f	8.05abc	9.60 cde
Acacia	74.9 b	0.34 bc	0.28 c	1.21 cd	8.85 abc	0.34 def	1.16 cde	8.85 abc	11.20 bcd
Poplar	83.3 ab	0.38 bc	0.30 bc	1.31 cd	9.90 abc	0.39 cde	1.33 bcd	9.90 abc	11.30 bcd
Sunflower	83.3 ab	0.43 bc	0.36 bc	1.38 cd	10.60 abc	0.50 bcd	1.58 bc	10.60 abc	11.95 bc
Jaman	83.3 ab	0.43 bc	0.55 ab	1.47 c	12.00 abc	0.59 abc	2.08 b	12.00 abc	12.75 b
Karir	100.0 a	0.70 ab	0.76 a	1.88 b	12.50 ab	0.66 ab	2.02 b	12.50 ab	13.30 b
Control/water	100.0 a	1.00 a	0.8 a	2.34 a	15.95 a	0.83 a	3.32 a	15.95 a	15.90 a
$LSD_{0.05}$	20.41	0.44	0.25	0.26	0.83	0.23	0.76	8.43	2.41

Table-2. Allelopathic influence of various plant extracts on plant height (cm), number of leaves (plant^{-1}), leaf area index (cm^2) and chlorophyll contents (µg cm^{-2}) of maize.

Treatments	Plant height (cm)		Number of leaves (plant^{-1})		Leaf area index (cm^2)		Chlorophyll contents (µg cm^{-2})	
	After 15 days	` After 30 days	After 15 days	After 30 days	After 15 days	After 30 days	After 15 days	After 30 days
Neem	12.12 g	12.12 g	2.83 e	3.00 c	11.90 h	34.96 f	12.00 f	15.05 e
Eucalyptus	14.71 g	14.71 g	3.35 ef	3.00 c	18.20 gh	41.57 ef	13.85 f	17.70 e
Tobacco	17.90 fg	17.90 fg	3.66 de	3.00 c	22.47 g	46.49 ef	16.85 ef	19.20 e
Indian lilac	21.66 ef	21.66 ef	3.77 cde	4.00 bc	27.55 fg	54.43 def	21.80 de	24.20 d
Acacia	24.46 df	24.46 df	4.02 cde	4.00 bc	32.89 ef	72.00 def	24.45 cd	28.54 dc
Poplar	27.26 cde	27.26 cde	4.24 bcd	5.50 b	39.98 df	82.92 cde	26.60 bcd	29.90 c
Sunflower	29.73 bcd	29.73 bcd	4.48 bc	5.50 b	47.87 cd	94.27 cd	27.05 bcd	32.95 bc
Jaman	31.68 bc	31.68 bc	4.75 b	5.50 b	52.99 bc	118.3 bc	30.65 bc	35.65 b
Karir	34.11 ab	34.11ab	4.86 b	7.50 a	61.11 b	137.2 b	32.55 b	36.55 b
Control/water	38.260 a	38.26 a	5.63 a	8.50 a	76.60 a	221.4 a	41.05 a	49.70 a
$LSD_{0.05}$	5.89	3.37	0.71	1.79	10.32	41.73	7.37	4.92

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