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ALLELOPATHIC POTENTIAL OF SENNA (*CASSIA ANGUSTIFOLIA* VAHL.) ON GERMINATION AND SEEDLING CHARACTERS OF SOME MAJOR CEREAL CROPS AND THEIR ASSOCIATED GRASSY WEEDS

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Abstract

Senna (*Cassia angustifolia* Vahl.) locally known as *Sana Makki* , an important medicinal plant, was investigated for its allelopathic potential against four major cereal crops i.e., maize, rice, sorghum and wheat as well as their associated grassy weeds viz., *Avena fatua*, *Dactyloctenium aegyptium*, *Echinocloa colona*, *Phalaris minor* and *Sorghum halepense*. Senna was employed as plant extract, mulch and soil incorporation along with control. Data on germination percentage (%), shoot length (mm), root length (mm), shoot fresh weight (g), root fresh weight (g), shoot dry weight (g), root dry weight (g) and number of leaves was recorded as measures of its allelopathic potential on these crops and their associated weeds. All senna treatments invariably affected germination and seedling growth characters of all crops and weed species under test. However, a remarkably pronounced effect was observed in senna-*Avena fatua* and senna-wheat interactions in which mulching of senna drastically reduced the germination of *Avena fatua* to 11% over control alongwith promoting all seedling growth characters of wheat crop. Hence, allelopathic potential of senna can be successfully employed to combat an invasive weed of wheat while at the same time mitigating the ill-effects of herbicidal use on economy, health and environment.

Introduction

Global concerns about herbicidal and pesticidal use, their residues in soil and plant systems as well as their hazardous effects on ecology and environment have diverted the attention of plant scientists to find eco-friendly approaches to plant protection against weeds, diseases and insects. The world is still in search of and in the process of developing farming techniques, which are sustainable for environment, crop production and protection as well as socio-economic points of view. Integrated weed management is one of such approaches where allelopathy can play its eco-friendly role in weed management.

Allelopathy as defined by the International Allelopathy Society "any process involving secondary metabolites produced by plants, algae, bacteria and fungi that influence the growth and development of agricultural and biological systems" (Anon., 1996). The phenomenon though existing in nature since centuries has drawn special attention over couple of decades. In a developing country like Pakistan weeds inflict 20-30% losses in different crops on the average. On national level total monitory losses due to weeds exceed beyond Rs. 120 billion, whereas wheat alone accounts for more than 30 billion. According to a report, monetary value losses due to weeds in major cereal crops of Pakistan fall in the range of Rs. 30 billion, Rs.40 billion, Rs.4 billion and Rs.5 billion for wheat, rice, maize and gram, respectively (Anon., 2005).

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Table 1. Allelopathic effects of weeds on crops.

Weed	Crop	Type of inhibition
Comellina alyssum (flax weed)	Flax	Dry matter production
Setaria faberii (giant foxtail)	Corn	Growth and yield reduction
Rumex crispus (curly docks)	Corn, Sorghum	Growth, seedling growth
Agropyron repens	Corn	Mineral deficiency, particularly nitrogen and potassium reduced biomass, phosphorus deficiency
Cirsium arvense (Canada thistle)	Several crops	Seed germination
Asciepias syriaca (common milk weed)	Grain sorghum	Seedling growth, yield
Conyza canadensis	Corn	Growth, germination
Pteridium esculentum	Lucerne	Radical elongation
Datura stramoniuim	Sunflower	Seedling growth

Latest research on medicinal herbs and spices has brought out a number of herbs that have chemicals suitable for promoting or suppressing the growth and yield of surrounding plants (Table 1). *Datura stramonium* L., (Lovett *et. al*., 1981), *Carthamus rosea* L., (Vaughan & Vaughan, 1988), for example, have shown potential of allelopathy against certain weeds. Asad & Bajwa, (2005) studied the allelopathic potential of *Senna occidentalis* L. on *Parthenium* weed and concluded that *S. occidentalis* L., can be successfully cultivated to suppress *Parthenium* weed. Tehmina & Bajwa, (2005) tested efficacy of *Helianthus annus* L., for suppressing wheat weeds like *Phalaris minor, Chenopodium album, Coronopus didymus, Rumex dentatus* and *Medicago polymorpha* and concluded that stem and root extracts of *H. annus* L., caused 30-90% reduction in dry weight of the weeds, relative to the control. Ejaz *et al.,* (2004) tested allelopathic effect of Eucalyptus leaf extract on germination and growth of cotton (*Gossypium hirsutum*) and concluded that Eucalyptus boiled extract decreased cotton seed germination to 57% as compared to 97% in the check.

Herbal medicines are gaining importance globally. In Pakistan too, medicinal plants and spices are now being cultivated by farmers as crops that are replacing conventional crops. Senna cultivation is in its nascent phase. Senna can be grown on all kinds of soils, especially on light well drained soil. Senna is basically a plant of arid environment. It thrives best in warm sub tropical areas, usually cultivated in area of bright sunshine but scanty rains. Sowing time of senna varies in different parts of the country, but scheduled in such a way that flowering and pod formation time of the crop does not coincide with the monsoon season. Senna is a crop of multi-harvest, giving a total of 3-4 pickings of leaves and pods in a period of 5-6 months. A good crop of senna gives 10 q/ha of dry leaves and 5q/ha of pods under irrigation and good management practices. The yield under rainfed conditions is about 7 q/ha of leaves and 4 q/ha of pods. Traditionally, senna has been used in the form of dried powder or decoction as stimulant, vermifuge and cathartic, and for relieving habitual constipation.

Material and Methods

Experiment was conducted to determine the allelopathic effect of *Senna angustifola* Vahl., on the germination and seedling characters of major cereal crops of Pakistan, i.e., wheat, maize, rice and sorghum and their associated grassy weeds i.e., *Avena fatua, Dactyloctenium aegyptium, Echinocloa colona, Phalaris minor* and *Sorghum halepense* under greenhouse conditions of PGRP, NARC, Islamabad during winter 2005-06. Senna leaves and pods were harvested from senna crop at anthesis, dried and extract was

prepared by soaking the plant material in 10 liters of water. The extract was later diluted to desired concentrations.

The various treatments used were:
T-1: Control
T-2: Incorporation of the whole plant material in soil (10%w/w)
T-3: Mulching of the whole plant material on top of the soil (10% w/w)
T-4: Aqueous extract application of whole plant debris of Senna (*C. angustifolia* Vahl) (10% w/v)

The experiment was sown in potting trays in RCB design replicated thrice. Three plastic trays each with a matrix of 6x9 grooves of dimensions 5 x 4 x 4.3 cm^3 were filled with clay. Seeds of the cereals and their weeds were sown in November 2005. The pots were kept moistened by soaking. Data on seed germination (%), shoot length (cm), root length (cm), shoot fresh weight (g), root fresh weight (g), shoot dry weight (g), root dry weight (g) and number of leaves was recorded according to the standard procedure. The data for the individual parameters were subjected to ANOVA. The treatment means were separated using Fisher's protected Least Significant Difference (LSD) test as outlined by Steel & Torrie, (1980).

Results

a. Weeds response: The allelopathic response of Senna towards the grassy weeds is summarized in Table 2.

Seed germination (%): Mulching among rest of the treatments reduced germination of *Avena fatua* to the maximum of 11.12% over control while reduction due to soil incorporation and extract application was also in the ranges of 77.78 and 88.89. In case of *Dactyloctenium aegytium* extract application of senna reduced germination to 54.55% followed by that of soil incorporaioton and mulcing. In *Echinocloa colona*, however, soil incorporation of senna caused promotary effect on germination of the weed up to the extent of 150% over control. Sorghum weed also underwent considerable reduction in germination over control by all three treatments.

Shoot length (mm): Among the weeds under study, shoot length varied among treatments such that shoot length of *Avean fatua* was maximum in extract application of Senna (Table 2). This was followed by that of mulching, but it was statistically at par with that of soil incorporation and control. As for *Dactolectenium* shoot length was highest in extract application of Senna, followed by mulching and soil incorporation. Soil incorporation was, however, statistically at par with that of control. Shoot length of *Echinocloa colona,* was also highest in extract application of Senna, however, in case of *Sorghum helepens* shoot length was highest when Senna was incorporated in soil.

Shoot weight (g): Shoot weight of *Avean fatua* was maximum when Senna was applied as soil mulch (Table 2). *Dactolectenium* showed its maximum shoot weight when Senna was applied as extract. Mulching of Senna showed statistically significant results in *Echinocloa colona*. However, that of *Sorghum helepens* was maximum in case of soil incorporation.

Table 2. Germination, shoot and root growth parameters of weed plants as affected by various Senna treatments.

	Treatment	Test weed	Germination % over control	Shoot length (mm)	Shoot weight (g)	Shoot dry weight (g)	Root length (mm)	Root weight (g)	Root dry weight (g)	Number of leaves
		Avena fatua								
1.	Control		100.00	98.00ab	0.047b	0.066b	93.14ns	0.061b	0.059ab	2.43c
2.	Soil Incorp.		77.78	125.43ab	0.041b	0.014	156.43	0.049b	0.031b	2.00c
3.	Mulching		11.12	37.14b	0.437a	0.039	145.00	0.090ab	0.041b	3.00b
4.	Extract		88.89	186.57a	0.199b	0.077	162.14	0.15a	0.093a	3.57a
	LSD0.05			92.54	0.151	-	-	0.062	0.035	0.557
		Dactyloctenium aegyptium								
1.	Control		100.00	13.67c	0.005b	0.002c	29.83b	0.007	0.002b	1.67c
2.	Soil Incorp.		72.73	18.00c	0.007b	0.002c	25.67b	0.002	0.005a	2.83bc
3.	Mulching		63.64	32.50b	0.032b	0.007b	78.83a	0.022	0.001b	3.50b
4.	Extract		54.55	56.00a	0.167a	0.002a	51.83ab	0.067	0.011a	5.83a
	LSD0.05			9.43	0.067	0.0012	37.11	-	0.0012	1.52
		Echinocloa colona								
1.	Control		100.00	26.25c	0.012b	0.003	28.75b	0.004	0.001	2.00bc
2.	Soil Incorp.		150.00	31.75c	0.015b	0.004	35.25b	0.016	0.003	1.75.c
3.	Mulching		100.00	70.75b	0.143a	0.028	104.75a	0.069	0.019	4.75a
4.	Extract		80.00	141.75a	0.047b	0.016	129.75a	0.237	0.082	4.00ab
	LSD0.05			35.61	0.087	-	54.76	-	-	2.048
		Sorghum helepens								
1.	Control		100.00	76.87c	0.012b	0.024b	81.25	0.013b	0.026b	2.875a
2.	Soil Incorp.		75.00	201.25	0.168a	0.055a	110.75	0.102a	0.056a	3.375a
3.	Mulching		75.00	105.87b	0.048b	0.022b	94.75	0.044b	0.019c	3.000a
4.	Extract		75.00	89.37bc	0.00b	0.010c	82.12	0.006b	0.010d	1.625b
	LSD 0.05			**23.84**	**0.057**	**0.0033**	**-**	**0.033**	**0.0033**	**0.677**

Fig. 1. Floral structure of *Senna angustifolia* with pods and leaves, the plant parts mostly used in herbal and pharmaceutical industry.

Shoot dry weight (g): Shoot dry weight of *Avena fatua* was non-significantly affected by all senna treatments. Same was the case in *Echinocloa colona*, however, shoot dry weight of *Dactolectenium* and *Sorghum helepens* were significantly affected by all senna treatments. *Dactolectenium* showed its maximum shoot dry weight under extract application of senna followed by that of mulching. Soil incorporation and control were, however, statistically at par. Soil incorporation and extract most significantly affected *Sorghum helepens* for shoot dry weight, mulching and control were statistically at par whereas extract application showed least shoot dry weight.

Root length (mm): Root length of *Avena fatua* and *Sorghum helepens* were non-significantly affected by all senna treatments. Mulching and extract application of senna both significantly affected *Dactolectenium* and *Echinocloa colona*.

Root weight (g): Root weight of both *Dactolectenium* and *Echinocloa colona* were non-significantly affected by all treatemetns. Extract application of senna, however, showed maximum root weight in *Avena fatua* whereas *Sorghum helepens* root weight was most affected by soil incorporation of senna.

Root dry weight (g): Root dry weight of *Echinocloa colona* was non-significantly affected by all senna treatments. *Avena fatua* showed its maximum root dry weight under extract application followed by that of mulching and soil incorporation. Control treatment showed least root dry weight in *Avena fatua. Dactolectenium* showed its maximum root dry weight under extract application and soil incorporation. Root dry weight of *Sorghum helepens* was most affected by soil incorporation followed by that of control.

Number of leaves: Number of leaves were maximum in *Avena fatua* under extract application of senna followed by that of mulching. Statistically same results were found in *Dactolectenium* and *Echinocloa colona*. In *Sorghum helepens*, however, control, soil incorporation and mulching all three significantly affected number of leaves compared to extract and were, however, statistically at par to each other.

b. Crops response: The allelopathic response of Senna towards the major cereal crops is summarized in Table 3.

Seed germination (%): Germinaion of *Triticum aestivum* remained unaffected by extract application of senna, however, a minor reduction in germination was observed in cases of soil incorporation and mulching. In *Zea mays*, germination was increased above control by soil incorporation and mulching treatments keeping extract application to the level of 100% over control. In *Oryza sativa* germination was reduced appreciably by soil incorporation and mulching while no reduction over control in case of mulching. Germination pomotary behaviour of the same kind was observed in extract application of senna on *Sorghum bicolor*.

Shoot length (mm): Shoot length of all the four crops under study i.e., *Triticum aestivum*, *Zea mays*, *Oryza sativa* and *Sorghum bicolor* were significantly affected by mulching treatment of senna. Rest of the treatments invariably affected all the crops out of which control treatment showed minimum shoot length under control treatment of senna.

Shoot weight (g): Shoot weight of *Triticum aestivum* was significantly affected by soil incorporation followed by mulching. In *Zea mays* control and mulching treatments both significantly affected shoot weight. However, mulching treatment significantly affected shoot weight of both *Oryza sativa* and *Sorghum bicolor*.

Shoot dry weight (g): Shoot dry weight of *Triticum aestivum* and *Zea mays* was significantly affected by soil incorporation. However, *Oryza sativa* and *Sorghum bicolor* were significantly affected by mulching treatment.

Root length (mm): Root length of *Triticum aestivum* was non-significantly affected by all senna treatments. In *Oryza sativa* and *Sorghum bicolor* maximum root length was recorded under extract application of senna whereas mulching significantly affected root length of *Zea mays*.

Root weight (g): Root weight of *Triticum aestivum* was highest in soil incorporation and mulching but this was statistically at par with control, followed by extract application of senna. In *Zea mays* mulching showed its potential for root weight to highest followed by soil incorporation and control. All the four treatments did not significantly affect root weight of *Oryza sativa* and *Sorghum bicolor*.

Root dry weight (g): Root dry weight of *Triticum aestivum* was highest in mulching and all other three treatments was statistically at par. In *Zea mays* highest root dry weight was recorded in soil incorporation followed by mulching and control. Root dry weight of both *Oryza sativa* and *Sorghum bicolor* was maximum under mulching treatment followed by extract.

Number of leaves: Number of leaves of *Triticum aestivum* was highest under soil incorporation and mulching but statistically at par with each other. Number of leaves in *Zea mays* was highest in soil incorporation treatment. However, that of *Oryza sativa* and *Sorghum bicolor* were non-significantly effected by all the treatment under study.

Table 3. Germination, shoot and root growth parameters of major cereal crops as affected by various Senna treatments.

	Treatment	Test crops	Germination % over control	Shoot length (mm)	Shoot weight (g)	Shoot dry weight (g)	Root length (mm)	Root weight (g)	Root dry weight. (g)	Number of leaves
		Triticum aestivum								
1.	Control		100.00	130.00c	0.130c	0.007d	120.00	0.172ab	0.046b	2.89b
2.	Soil Incorp.		90.91	256.11a	0.384a	0.062a	97.77	0.242a	0.092b	4.11a
3.	Mulching		81.81	239.67a	0.197b	0.054b	133.89	0.196a	0.176a	3.78a
4.	Extract		100.00	155.89b	0.114c	0.020c	117.00	0.110b	0.057b	2.55b
	LSD0.05			25.90	0.0688	0.0031	-	0.075	0.0688	0.546
		Zea mays								
1.	Control		100.00	169.091c	1.155a	0.107b	134.091ab	0.575b	0.281bc	2.82b
2.	Soil Incorp.		109.10	215.455b	0.522b	0.180a	130.00b	0.551b	0.412a	2.90b
3.	Mulching		109.10	263.455a	1.145a	0.215a	172.273a	0.871a	0.307b	3.54a
4.	Extract		100.00	178.182bc	0.258c	0.130b	90.909c	0.272c	0.245c	2.45b
	LSD0.05			39.91	0.258	0.0389	38.55	0.2203	0.0551	0.502
		Oryza sativa								
1.	Control		100.00	50.17b	0.021b	0.006b	61.33b	0.029	0.012c	2.00
2.	Soil Incorp.		33.34	45.00b	0.009b	0.004c	29.00c	0.078	0.006c	3.00
3.	Mulching		100.00	124.33a	0.127a	0.033a	59.33b	0.073	0.027a	3.33
4.	Extract		16.67	53.67b	0.104ab	0.004c	131.17a	0.063	0.017b	3.00
	LSD0.05			14.91	0.087	0.039	19.06	-	0.0039	-
		Sorghum bicolor								
1.	Control		100.00	50.17b	0.021b	0.006b	61.33b	0.029	0.012c	2.00
2.	Soil Incorp.		75.00	45.00b	0.009b	0.004c	29.00c	0.078	0.006c	3.00
3.	Mulching		75.00	124.33a	0.127a	0.033a	59.33b	0.073	0.027a	3.33
4.	Extract		125.00	53.67	0.104ab	0.004c	131.17a	0.063	0.017b	3.33
	LSD 0.05			**14.91**	**0.087**	**0.0039**	**19.06**	-	**0.0039**	-

Discussion

Mulching of senna had a clear positive effect on the seedling growth characteristics of maize, rice and sorghum; however, in case of wheat soil incorporation gave better seedling growth than mulching in comparison to control (Table 3). However, both of these treatments reduced wheat germination by 10 and 20%, respectively compared to control. The reduction in germination in case of sorghum crop was about 25%, whereas, both the treatments enhanced the germination of maize crop. The germination of *Sorghum bicolor* was enhanced by 25% over the control by senna extract application.

The germination of tested grassy weeds were reduced by senna treatments in case of *Avena fatua, Dectyloctenium aegyptium* and *Sorhgum helepens*, whereas in case of *Echinocloa colona* its germination was reduced by soil incorporation and extract application.

The senna extract in general were growth promoter for *Avena fatua, Dectyloctenium aegyptium* and *Echinocloa colona* and only soil incorporation in case of *Sorhgum helepens.* Mulching of senna reduced the *Avena fatua* germination drastically to 11% over control which may be employed as its population control management strategy (Table 2), though this treatment significantly reduced the shoot length to minimum (37 mm), other growth characters of seedling remained less effected (Table 2).

It is interesting to note that *Avena fatua* is important weed of wheat, where its germination is reduced to 11% by senna mulching, while the same treatment is affecting germination of wheat by 20%, but at the same time contributing positively to crop plants shoot length, root length, root biomass and number of leaves. If wheat germination is compensated by using higher seed rate, it is possible to smother out the few poorly growing weed plants, enabling to develop an integrated weed management approach using allelopathic potential of senna. However, this study needs further evaluation at field level.

Conclusion

From the present study it was concluded that various applications of Senna can be successfully used in weed control management of weed, especially for *Avena fatua* in wheat cultivation. Use of medicinal plants like Senna as allelopathic agent will be a new but eco friendly, cheaper and effective mode of weed control. Further studies are necessary to encompass reactive ingredient of Senna in extract and mulch formulation to understand the different behavior and plant response to its application.

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