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ALLELOPATHIC POTENTIAL OF SORGHUM WATER EXTRACT AND IT'S MULCHING ON *ECHINOCHLOA COLONA* (L.) LINK IN MAIZE

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Abstract

Sorghum allelopathy can be a vital tool in curbing weeds in maize as substitute to hazardous chemical weedicides to mitigate environmental pollution. The main objective of this study was to evaluate the efficacy of sorghum water extracts (SWE) and sorghum mulch (SM) for controlling *Echinochloa colona* (L.) Link (jungle rice) in hybrid maize (HC-8080). For this purpose, a field experiment was executed with allelopathic treatments which were SWE @ 15 L ha^{-1} (foliar sprayed at 15 days after sowing (DAS), SWE @ 15 L ha^{-1} (sprayed at 15 & 30 DAS), SWE @ 15 L ha^{-1} (sprayed at 15, 30 & 45 DAS), SM @ 8 t ha^{-1}, SM @ 8 t ha^{-1} + SWE @ 15 L ha^{-1} and control. Results showed that SWE @ 15 L ha^{-1} (sprayed at 15, 30 & 45 DAS) reduced jungle rice weed density by 65%, its fresh weight by 49% and dry weight by 58% as compared control. Besides, this treatment increased number of grains cob^{-1}, 1000-grains weight and grains yield each by 25% over control. However, application of SM @ 8 t ha^{-1} alone was not very effective but gave better results when combined with SWE@ 15 L ha^{-1}. It was concluded that sorghum water extract can be used as natural jungle rice weed inhibitor in maize.

Key words: Sorghum water extract, Sorghum mulching, Jungle rice, Maize.

Introduction

Maize (*Zea mays* L.) is most important cereal crop in the world as far as its production per unit area is concerned. In Pakistan, it occupies an inevitable position in terms of industrial food products and as a ration for the domestic animals (Khaliq *et al.*, 2011). During the year 2017, its production increased by 16.3% over the last year, which was prominently due to the increase in area under cultivation (Anonymous, 2017). However, yield potential of maize in Pakistan is still lower than international standards due to several reasons like un-balance nutrient inputs and their high cost, plant pathogens, weeds infestation etc. Among the various yield reducing factors, weed infestation and its interference has been reported to be the most deleterious one. It has been reported that shortage of available resources due to weed competition resulted in 29% and 13% grain yield losses in maize with and without other control measures, respectively (Ali *et al.*, 2003). Chemical weed control is expensive and causes environmental pollution. Therefore, there is need to look for an eco-friendly, less laborious and effective weed control technique like sorghum allelopathy for effective weed control in summer maize (Razzaq *et al.*, 2010).

Allelopathy is an organic approach for controlling weeds to improve crop yields and ensure sustainability of ecosystem (Hamid *et al.*, 2017). Allelo-chemicals occur almost in all plant tissues like leaves, seeds and fruits, flowers, etc., and can be released together in the form of secondary metabolites (Mustafa *et al.*, 2019). Allelopathy can be used as spray of allelopathic plant aqueous extracts, allelopathic crop mulch, alleopathic crop soil incorporation and in crop rotation (Bhowmik & Inderjit, 2003). Among other allelopathic crops, sorghum (*Sorghum bicolor* (L.) Moench has a commendable degree of allelochemicals in the form of cyanogenic glucosides and phenolic compounds released from its root, stem and leaves and even from the plant residues suppressing growth of weeds (Cheema *et al.*, 2007). According to Ashraf & Iqbal (2006) fresh and dry weight of weeds can be lowered with the soil incorporation of sorghum herbage and application of sorghum water extracts that in turn improved wheat yield up to 30%. Cheema *et al.*, (2004) reported 38-49% reduction in dry weight of weeds when they sprayed sorghum water extracts twice after 30 and 60 DAS. However, use of sorghum allelopathic characteristics to control jungle rice weed in hybrid irrigated maize is not yet studied. Therefore, the objective of the present study is to evaluate the efficacy of sorghum (*Sorghum bicolor* (L.) Moench) water extracts and sorghum mulch for controlling jungle rice in hybrid maize.

Materials and Methods

The experiment was conducted at student research area of department of Agronomy, Faculty of Agriculture, Gomal University, Dera Ismail Khan, during summer (Kharif) season of 2017 on hybrid maize (HC-8080). Allelopathic treatments were sorghum water extract (SWE) @ 15 L ha^{-1} (foliar sprayed at 15 days after sowing (DAS)), SWE @ 15 L ha^{-1} (sprayed at 15 & 30 DAS), SWE @ 15 L ha^{-1} (sprayed at 15, 30 & 45 DAS), sorghum mulch (SM) @ 8 t ha^{-1} and SM @ 8 t ha^{-1} + SWE @ 15 L ha^{-1}. A weedy check (control) was also kept for comparison. Experiment was laid out in randomized complete block design with four replicates. The net plot size was 12 m^2. Maize seeds were sown @ 25 kg ha^{-1} on ridges at Row to Row distance of 60 cm and Plant to Plant distance of 25 cm. The SWE was prepared by soaking small pieces of sorghum shoot in distilled water (1:10 w/v) for 48 hours.

The aqueous extract was then filtered and separated as suggested by Cheema & Khaliq (2001). Sorghum was harvested at physiological maturity, cut into small pieces and spread as mulch in maize field in allocated plots. Weeds other than jungle rice *Echinochloa colona* (L.) Link were eradicated by hand weeding. All other agronomic practices were kept as per recommendations for the area. Data were recorded for weed density (m^{-2}), fresh and dry weed weight (g m^{-2}), as well as maize grains cob^{-1}, 1000-grains weight (g) and grain yield (kg ha^{-1}).

The data regarding weed and maize parameters were subjected to Analysis of Variance (ANOVA) at 5% significance level and Fisher's protected test was used to determine differences among means of all treatments applied (Steel *et al*., 1997). The software statistix. 8.1 was used for statistical analysis.

Results

Weed density (m^{-2}): Results revealed that the applied treatments significantly lowered the population density of *Echinochloa colona* (L.) Link its fresh and dry weight as compared to control (Table 1). Three sprays of SWE @ 15 L ha^{-1} showed maximum reduction (65%) over control than other treatments. SM @ 8 t ha^{-1} also proved beneficial in controlling weed density and caused an overall reduction of 38% over control. Likewise, integration of SWE @ 15 L ha^{-1} and SM @ 8 t ha^{-1} performed better (56% reduction) than single spray (26%) at 15 DAS and two sprays (41%) of SWE at 15 and 30 DAS. However, the impact of SWE was found more convincing than the sole application of SM @ 8 t ha^{-1}.

Fresh and dry weed weight (g): The SWE sprayed thrice at 15, 30 and 45 DAS showed maximum inhibition (49% and 58%, respectively) in terms of fresh and dry weight of jungle rice as compared to control. Similarly, combined inhibitory effect of SWE and SM was more profound in reducing the fresh and dry weight by 33% and 43%, respectively relative to single spray and two sprays of SWE (21% and 22% & 30% and 35%, respectively) over control. Moreover, SM @ 8 t ha^{-1} when applied alone was better than single SWE spray in reducing fresh and dry weed weight which was 26% and 28%.

Number of grains (cob^{-1}): The results showed significant difference in maize grains cob^{-1}, 1000-grains weight (g) and grain yield (kg ha^{-1}) among treatments (Table 2). Maximum number of grains $cob^{-1}$was recorded in treatment with thrice application of SWE @ 15 L ha^{-1} (15, 30 & 45 DAS). This treatment enhanced grains $cob^{-1}$by 25% (343 grains cob^{-1}) than the weedy check plots (258 grains cob^{-1}) and stood better among all others. Combined use of SWE @ 15 L ha^{-1} and SM @ 8 t ha^{-1}produced the next higher grains (312 grains cob^{-1}) showing an overall increase of 17% over control. This combination surpassed one and two sprays of SWE which respectively recorded 10% (288 grains cob^{-1}) and 17% (311 grains cob^{-1}) enhancement in grains cob^{-1}. The SM @ 8 t ha^{-1} alone produced the least grains (279 grains cob^{-1}) which were however 7% more as compared to control.

1000-grains weight (g): The maize 1000-grain weight (189 g) was 26% higher in thrice application of SWE @ 15 L ha^{-1} (15, 30 & 45 DAS) over control (140 g). Two sprays of SWE @ 15 L ha^{-1} (15 and 30 DAS) and combination of SWE @ 15 L ha^{-1} + SM @ 8 t ha^{-1}increased the maize grain weight by 17% and 16% respectively over control by producing 169 g and 168 g of 1000 grains weight, respectively. The maize 1000-grains weighing 159 g (12% heavier than control) were obtained with single spray of SWE @ 15 L ha^{-1}. However, lightest 1000-grains weight of 153 g was obtained by SM @ 8 t ha^{-1} treated plots which were 88% heavier than control.

Grain yield (t ha^{-1}): Thrice application of SWE @ 15 L ha^{-1} (15, 30 & 45 DAS) gave maximum grains yield (3.99 t ha^{-1}) relative to other treatments. An increase of 26% was depicted in the said treatment over control (2.97 t ha^{-1}). The combined application of SWE @ 15 L ha^{-1} + SM @ 8 t ha^{-1}stood second in this regard with an enhancement in grain yield of 15% (3.51 t ha^{-1}) as compared to control. Likewise, two spray of SWE @ 15 L ha^{-1} (15 & 30 DAS) recorded 3.41 t ha^{-1} grain yield (13% higher than control). However, the grain yield of SWE @ 15 L ha^{-1} (15DAS) (3.17 t ha^{-1}) and SM @ 8 t ha^{-1} (3.14 t ha^{-1}) showed a respective enhancement of 6% and 5% in comparison with control.

Table 1. Density (m^{-2}), fresh weight (g m^{-2}) and dry weight (g m^{-2}) of jungle rice as affected by sorghum water extract and sorghum mulch.

Treatments	*E. colona* density (m^{-2})	Fresh weight (g m^{-2})	Dry weight (g m^{-2})
Weedy check (control)	23.8 a	86.7 a	78.34 a
SM @ 8 t ha^{-1}	14.8 bc (-38%)	63.9 c (-26%)	56.3 c (-28%)
SWE @ 15 L ha^{-1} (15DAS)	17.5 b (-26%)	68.7 b (-21%)	60.8 b (-22%)
SWE @ 15 L ha^{-1} (15 & 30 DAS)	14.0 bc (-41%)	60.4 d (-30%)	51.1 d (-35%)
SWE @ 15 L ha^{-1} (15, 30 & 45 DAS)	8.3 d (-65%)	44.6 f (-49%)	33.2 f (-58%)
SWE @ 15 L ha^{-1} + SM @ 8 t ha^{-1}	10.5 cd (-56%)	58.1 e (-33%)	45.0 e (-43%)
$LSD_{0.05}$	**4.6**	**1.2**	**2.2**

Level. Values between parentheses in the same column represent relative decrease as compared to the control
SM = Sorghum mulch, SWE = Sorghum water extract, DAS = Days after sowing

ANOVA for weed density (m^{-2}), fresh weight (g) and dry weight (g).

Source	Df	Weed density (m^{-2})				Fresh weight (g)				Dry weight (g)			
		SS	MS	F	P	SS	MS	F	P	SS	MS	F	P
Rep	3	3.000	1.000			42.67	14.222			13.50	4.500		
Tr	5	603.333	120.667	12.84	0.0001	3856.46	771.292	1239.58	0.0000	4668.49	933.699	444.62	0.0000
Error	15	141.000	9.400			9.33	0.622			31.50	2.100		
Total	23	747.333				3908.46				4713.49			

Grand mean = 14.833; CV = 20.67; Grand mean = 63.722; CV = 1.24 Grand mean = 54.115; CV = 2.68

Table 2. Effect of sorghum water extract and sorghum mulch on number of grains cob^{-1}, 1000 grain weight (g) and grain yield (t ha^{-1}) of maize.

Treatments	Number of grains cob^{-1}	1000 grain weight (g)	Grain yield (t ha^{-1})
Weedy check	258 d	140 e	2.97 d
SM @ 8 t ha^{-1}	279 cd (+7%)	153 d (+8%)	3.14 cd (+5%)
SWE @ 15 L ha^{-1} (15DAS)	288 c (+10%)	159 cd (+12%)	3.17 cd (+6%)
SWE @ 15 L ha^{-1} (15 & 30 DAS)	311 b (+17%)	169 b (+17%)	3.41 bc (+13%)
SWE @ 15 L ha^{-1} (15, 30 & 45 DAS)	343 a (+25%)	189 a (+26%)	3.99 a (+26%)
SWE @ 15 L ha^{-1} + SM @ 8 t ha^{-1}	312 b (+17%)	168 bc (+16%)	3.51 b (+15%)
LSD$_{0.05}$	**22.1**	**8.6**	**0.28**

Values between parentheses in the same column represent relative increase as compared to the control
SM = Sorghum mulch, SWE = Sorghum water extract, DAS = Days after sowing

ANOVA for number of grains (cob^{-1}), 1000-grain weight (g) and grain yield (kg ha^{-1}) in maize.

Source	Df	Number of grains (cob^{-1})				1000-grain weight (g)				Grain yield (kg ha^{-1})			
		SS	MS	F	P	SS	MS	F	P	SS	MS	F	P
Rep	3	2630.5	876.82			1142.76	380.92			3.5604	1.1868		
Tr	5	17618.9	3523.77	16.42	0.0000	5350.95	1070.19	32.78	0.0000	2.6676	0.5335	14.58	0.000
Error	15	3218.3	214.55			489.72	32.65			0.5490	0.0366		
Total	23	23467.6				6983.43				6.7771			

Grand mean = 248.38; CV = 5.90; Grand mean = 162.89; CV = 3.51; Grand mean = 3.364; CV =5.69

Discussion

The undue use of chemical herbicides for controlling weeds has spurred the researchers worldwide in order to devising methods which would not only control weed population but also ensure sustainability of the ecosystem. Different methods have been adopted of which allelopathy has proved as an appropriate and feasible method for this purpose. In the present study various weed control treatments have been examined against jungle rice using SWE and SM, wherein all the treatments showed significant results for the studied parameters. Weed density and fresh and dry weight of jungle rice were maximally reduced where three sprays of SWE were applied after 15 days interval. The observed inhibitory effect might be due the strong allelochemicals present in sorghum plant. Sorghum plant residues are reported to be allelopathic in nature as they release certain phytochemicals during the process of decomposition (Cheema & Khaliq, 2000). Cheema *et al*., (2007) reported the release of certain cyanogenic glucosides from sorghum plants which are inhibitory in action. In an experiment, Khaliq *et al*., (2011) incorporated sorghum and sunflower residues in the soil for controlling *Trianthema portulacastrum* and reported that sorghum plant residues had a more suppressive effect on weed than the sunflower residues. Our results are also in accordance with Cheema & Khaliq (2001) who stated that weed density can be efficiently controlled by using SWE. The significant reduction in fresh and dry weight of *E. colona* advocates that sorghum plant has an acute tendency towards suppressing weed growth which is indicative of its robust allelopathic potential. These results were in line with the findings of Hussain *et al*., (2014) who reported convincingly lower fresh and dry weed weight when treated with SWE. Cheema & Irshad (2004) also reported similar results in rice crop for barnyard grass.

All the treatments reduced jungle rice population and its biomass therefore improved utilization of resources by maize. Three sprays of SWE showed a corresponding increase in the number of grains (cob^{-1}) and 1000-grains weight. The suppression of weeds by the treatments might have provided ample opportunity to maize for acquiring sufficient nutrients applied in order to produce more grains and gain an acceptable grain size and weight. Afzal *et al*., (2014) found a significant increase in grains cob^{-1} in maize with various plant water extracts including sorghum. Similarly, Cheema & Khaliq (2001) recorded heavier 1000-seed weight in mung bean with three sprays of SWE.

Three sprays of SWE @ 15 L ha^{-1} (15, 30 & 45 DAS) suppressed the weed density, maximum fresh and dry weight (Table 1) and enabled the maize plants to utilize the inputs efficiently for attaining maximum grains cob^{-1}, 1000 grains weight and grain yield. Cheema & Khaliq (2001) achieved 18% more grain yield in mung bean when they sprayed SWE at 20, 30 and 40 DAS.

Conclusion

The study concludes that all the subjugated the growth and development of the jungle rice. However, sorghum water spray used thrice for this purpose, was most effective in this regard. In addition, thrice application of sorghum water extract maximally reduced all the weed parameters and enhanced maize yield. Sorghum residues used as mulch combined with sorghum water spray were better for enhancing yield and other parameters than the sole application of sorghum mulch. Nevertheless, sorghum water extract can be used for natural and economical control of jungle rice for better crop husbandry.

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