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IMPACT OF RICE EXTRACT TYPE, CONCENTRATION AND APPLICATION TIME ON WEEDS BIOMASS AND GRAIN YIELD OF WHEAT

Imran Khan[1,*], Shad Khan Khalil, Abdul Rab, Akhtar Ali, Faisal Khan, Izhar Ali and Syed Junaid Ahmad

ABSTRACT

Higher weeds infestation is one of the major yield reducing factors. Synthetic herbicides are generally used for weed control. However, their uses may sometimes lead to environmental pollution as well. Alternative strategies are needed for management of weeds to overcome the problems created by synthetic chemicals. Field experiment was conducted at the Agronomy Research Farm of the University of Agriculture Peshawar, Pakistan during 2014-15 to assess the effect of rice water extract (RWE) on weeds' weight and yield of wheat. Three concentrations i.e. 1:3, 1:4 and 1:5 kg: L^{-1} of stem and leaf extracts of rice were applied at three stages (emergence, tillering and half at emergence + half at tillering) of the crop. Hand weeding (HW), herbicides and control (no weeding) plots were also included for comparisons. Herbicides treated and HW plots produced lighter weeds biomass, more tillers, longer spikes and more grain yield of wheat compared with RWE treated plots, whereas RWE was more effective compared with control. The RWE at 1:3 concentration drastically reduced weeds biomass and increased number of tillers m^{-2}, spike length and grain yield. The RWE sprayed at emergence resulted in lower weeds weight, more tillers m^{-2}, longer spike and higher yield. Leaf water extract was more effective than stem water extract. It is concluded that RWE has the capability to be used for control of weeds. Leaf water extract of rice at 1:3 sprayed at emergence reduced weeds biomass and increased number of tillers m^{-2}, spike length and grain yield of wheat.

Key words: Grain yield, rice leaves, spike length, stems extract, weeds biomass, wheat.

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[1]Dept. of Agronomy, The University of Agriculture, Peshawar, Pakistan.
*Corresponding author's email: ikhan.agr@aup.edu.pk

INTRODUCTION

Wheat is an important cereal cultivated for grain production. It is also grown for fodder due to its digestibility and palatability (Hossain *et al*., 2003). Wheat yield (2775 kg ha^{-1}) is low in Pakistan compared with other major wheat producing countries (MNFSR, 2014). Besides other problems high weeds infestation is one of the major problems which reduces the yield of wheat (Jabran *et al.*, 2011). Weeds cause huge losses in wheat yield if not managed (Akbar *et al*., 2011; Razzaq *et al.*, 2010; Khan *et al.,* 2009). An annual loss of Rs. 30 billion estimated in Pakistan in wheat due to high weeds infestation (Afridi *et al.*, 2014 and Afridi and Khan, 2015).

Weeds control through synthetic herbicides is a very effective practice and offer a considerable boost in crop yield (Santos, 2009). However, non-judicious use of herbicides causes water and soil pollution, creates resistance in weeds towards herbicides and human and animal health apprehension (Farooq *et al*., 2011; Jabran *et al.,* 2008). These factors force researchers to find alternative methods for weed control (Farooq *et al.,* 2011; Bhadoria, 2011). Natural chemicals (extracts) and allelopathy could be an effective technique for decreasing use of synthetic herbicides for weed contrtol (Khan *et al.,* 2016; Bhadoria, 2011; Farooq *et al.,* 2008; Hussain *et al*., 2007).

Allelopathy is a natural and ecosystem friendly practice for controlling weeds and increase yields of crops. Rice herbage can effectively control dicot and monocot weeds under open field conditions (Olofsdotter, 2001). Stem, leaves, roots and seed hulls of rice plants have the allelopathic effect (Kim *et al*., 2005). Allelochemicals isolated from rice includes phenolic compounds such as mandelic acid, p-salicylic, p-hydroxybenzoic, p-coumaric, syringic, vanillic, ferulic, momilactone-B and steriods (Macias *et al*. 2006; Kato-Noguchi and Ino, 2005; Kato-Noguchi *et al*. 2002).

Rice plants water extract effectively control the growth and germination of many weeds species under the laboratory condition (Chou *et al*., 1991). Ahn and Chung (2000) found inhibitory effect of rice methanol extract on growth and germination of lettuce and *Echinochloa crus-galli*. Water extracts of rice, sunflower, sorghum and brassica mixed with one third dose of herbicides effectively reduced population and dry matter production of weeds and increased grain yield (Elahi *et al.,* 2011). The present study was carried out to evaluate the effect of rice extract type, concentration and application time on weeds biomass and grain yield of wheat.

MATERIALS AND METHODS

The experiment was carried out at Agronomy research farm, University of Agriculture Peshawar in the year 2014-15. Experiment

was laid out in a randomized complete block design having three replications. A net plot size of 5.4 m^2 each having six rows was used. Wheat variety Atta Habib-2010 was planted on November 26, 2014. A basal dose of 120 kg nitrogen and 90 kg phosphorous ha^{-1} in the form of urea and diammonium phosphate (DAP) were applied respectively. Half of nitrogen and all of the phosphorous were applied at sowing, while remaining half of nitrogen was applied at 1st irrigation. Wheat was harvested on 10th of May, 2015. Three rice stem and leaf concentration (1:3, 1:4 and 1:5) were sprayed by knapsack hand sprayer fitted with flat fan nozzle at three stages (100% at emergence, 100% at tillering, half at emergence + half at tillering). Control plots (weedy check) were kept in experiment for comparison. Herbicides Buctril super 60EC (bromoxynil + MCPA) at the rate 1.5 L a.i ha^{-1} for broad leaves and Puma super 75EW (fenoxaprop-P-ethyl) at the rate of 1.25 a.i ha^{-1} for narrow leaves weeds were applied 48 days after sowing in herbicide treated plots. Weeds were uprooted 50 and 70 days after sowing in hand weeded plots. All other agronomic practices such as irrigation, land preparation were applied uniformly.

The following factors along with their respective levels were studied. Rice extract type (RET) as Factor A including stem water extract (SWE) and leaf water extract (LWE). Concentration of extract (C) (w/v) as Factor B having three levels i.e. C_1 = 1:3 (1 kg rice part and 3 liters of water), C_2 = 1:4 (1 kg rice part and 4 liters of water) and C_3 = 1:5 ((1 kg rice part and 5 liters of water). The application timing (AT) as Factor C with three levels viz. AT_1 = full at emergence, AT_2 = full at tillering and AT_3 = half at emergence + half at tillering.

Preparation of rice parts (stem and leaves) water extracts of different concentration

Herbage of rice was obtained from Agronomy research farm, the University of Agriculture Peshawar and were used for preparation of water extracts for experiment. The rice herbage were split into leaves and stems and after sun drying for 2 days, were chopped into 3 cm pieces. Then the 3 cm pieces of rice parts (stems and leaves) were soaked in water separately by maintaining 1:3, 1:4 and 1:5 (i.e 1 kg of rice part in 3 liters, 1 kg rice part in 4 liters water and 1 kg rice part in 5 liters water) for 36 hours for making different concentration of rice water extracts.

Statistical analysis

The data were analyzed statistically using analysis of variance techniques appropriate for randomized complete block design (RCBD). Least significant differences (LSD) test was used to compare means at $P \leq 0.05$, when F-values were significant (Jan *et al*., 2009).

RESULTS AND DISCUSSION

Weeds fresh weight (g m^{-2})

Rice extract type (RET), concentration (C), and application time (AT) significantly influenced fresh weeds weight (WW) 80 days after sowing (DAS), while all the interactions were non-significant (Table-1). Herbicide application significantly reduced WW (23.77g m^{-2}) compared with rice water extract (RWE) sprayed plots (116.93g m^{-2}). Similarly hand weeding resulted in lower WW (33.9g m^{-2}) compared with RWE sprayed plots (116.93g m^{-2}). Whereas, RWE significantly decreased WW (116.93g m^{-2}) 80 DAS compared with control (145.87g m^{-2}). Our results are in line with Khan and Khan (2012), who reported more weeds biomass in control plots compared with water extract of *Phragmites australis*. Among C, lower WW (79.76 g m^{-2}) was noted in plots treated with 1:3, whereas higher WW (140.36 g m^{-2}) 80 DAS was recorded from RWE applied at 1:5. The increased in WW may be due to application of lower amount of allelochemicals (Chon and Kim, 2004). These findings are in conformity with Saleem and Fawasi (1993) who reported that high concentration of sorghab inhibited germination and growth of weeds, while lower concentration promotes their growth. RWE sprayed at emergence drastically decreased WW (112 g m^{-2}), while significantly higher WW (122.71 g m^{-2}) 80 DAS was noted with RWE applied half at emergence + half at tillering. Our results are in line with Cheema *et al*. (2010) who concluded that rice husk extract was more effective in early stages, which significantly reduced weeds dry weight. Leaf water extract (LWE) resulted in lower WW (115.02 g m^{-2}) 80 DAS compared with stem water extract (SWE) (118.85 g m^{-2}). These results are in conformity with Jafari *et al*. (2011) who concluded that leaf water extract was more effective than stem and root water extracts.

Tillers (m^{-2})

Rice extract type (RET), C and AT significantly affected numbers of tillers, whereas all the interactions were non-significant (Table-2). Hand weeded and herbicides treated plots resulted in more tillers (337 m^{-2} and 351 m^{-2}) respectively than RWE treated plots (304 m^{-2}), however RWE treated plots produced more tillers (304 m^{-2}) than control (266 m^{-2}). These results are in conformity with Awan *et al*. (2012) who reported less number of tillers in control compared with reduced dose of herbicide + sorghab water extract. Our results are also in line with Khan *et al*. (2015) who reported maximum tillers from hand weeded plots followed by sorghab, while minimum tillers were noted in control. Application of 1:3 RWE resulted in more tillers (332 m^{-2}), while plots treated with 1:5 RWE resulted in less number of tillers (287 m^{-2}). The decrease in number of tillers might be due to the presence of more weeds in plots treated with lower concentration of

RWE. Among AT, application of RWE at emergence and tillering resulted in more number of tillers (309 m^{-2} and 308 m^{-2}), while less number of tillers (296 m^{-2}) were produced in plots treated with RWE half at emergence + half at tillering. Rice extract type indicated that leaf water extract resulted in significantly more tillers (308 m^{-2}) than stem water extract (300 m^{-2}). The increase in number of tillers may be attributed to sufficient amount of nutrients availability due to decreased competition of weeds with wheat crop.

Spike length (cm)

Rice extract type (RET), C and AT significantly affected spike length, while RHT × C, RHT × AT, C × AT and RHT × C × AT interactions were non-significant (Table-3). Plots treated with herbicide resulted in significantly long spike (10.35 cm) compared with rice water extract (RWE) treated plots (9.95 cm). Likewise hand weeded plots produce longer spike (10.3 cm) than RWE treated plots (9.95 cm). Whereas, RWE plots produce significantly long spike (9.95 cm) compared with control (9.78 cm). RWE applied at 1:3 resulted in significantly longer spike (10.17 cm), while each decreased in C reduced spike length and plots treated with 1:5 RWE resulted in small spikes (9.75 cm). RWE sprayed at emergence and tillering resulted in statistically similar spike length (9.99 and 9.96 cm), while RWE applied half at emergence + half at tillering resulted in significantly smaller spike (9.9 cm). Plots treated with leaf water extract (LWE) produced longer spikes (9.99 cm), while plots treated with stem water extract (SWE) produced smaller spikes (9.91 cm). The increase in spike length might be attributed to better weeds control that resulted in sufficient availability of resources for wheat. Our results are in line with Ashraf and Akhlaq (2007) who reported longer spikes in hand weeded and herbicides treated plots compared with sorghum water extract treated plots, while sorghum water extracts treated plots resulted in significantly longer spike than control. These results are in line with Cheema *et al*. (2002) who reported longer spikes from sorghum water extract compared with control.

Thousand grains weight (g)

Thousand grains weight was significantly influenced by C and AT whereas RET and all the interactions were non-significant (Table-4). Herbicides treated plots produced significantly heavier grains (43.78 g) compared with rice water extract (RWE) while hand weeding resulted in statistically identical thousand grains weight (42.55 g) compared with RWE. Plots treated with RWE produced heavier thousand grains weight (41.36 g) compared with control (37.43 g). The possible reason for the increased grain weight might be less or no competition with weeds due to less number of weeds. Similar results were obtained by Elahi *et al*. (2011) who reported that more thousand

grain weight was obtained in herbicides treated plots followed by rice + brassica + sunflower water extract mixed with one third dose of herbicide while minimum thousand grains weight was produced in control. Results are also in line with Jabran *et al*. (2010) who revealed that heaviest grains was produced with application of sunflower and sorghum water extract with 1/3rd dose of herbicide while lower grains weight was recorded in control. Application of 1:3 RWE resulted in heavier grains (43.3 g) while lower thousand grains weight (39.5 g) was recorded in plots treated with 1:5 RWE. Spraying of RWE at emergence resulted in significantly more thousand grains weight (42.03 g) while RWE applied half at emergence + half at tillering resulted in lower thousand grains weight (40.79 g). Leaf and stem water extracts resulted in statistically identical thousand grains weight (41.6 and 41.1 g) respectively. The reason of lower thousand grains weight might be more competition with weeds. The results are accordance with Iqbal *et al*. (2010) who obtained more 1000-grains weight from application of 18 L ha^{-1} sorghum + sunflower + brassica water extract with half dose of herbicide, followed by 15 L ha^{-1} sorghum+sunflower+brassica water extract with half dose herbicide.

Grain yield (kg ha^{-1})

Rice extract type (RET), C and AT significantly affected grain yield, while all the interactions were non-significant (Table-5). Herbicides and hand weeding significantly increased the grain yield (4022 kg ha^{-1} and 3872 kg ha^{-1}) respectively compared with RWE (3114 kg ha^{-1}) whereas RWE produced more grain yield (3114 kg ha^{-1}) compared with control (2417 kg ha^{-1}). Lower grain yield in control might be due to unchecked weeds throughout the growing season which resulted in low yield components. Similar results were reported by Elahi *et al*. (2011) who stated that herbicide treated plots produced more grain yield which was statistically alike with application of water extract of rice + brassica + sunflower combined with one third dose of herbicide and rice + sorghum + sunflower with one third dose of herbicide, while lower grain yield was noted in control. Our findings are in line with Rehman *et al*. (2010) who observed more grain yield from plots treated with recommended dose of herbicides, followed by application of rice + sorghum + sunflower water extract with half dose of herbicides and less grain yield was obtained from control. Our results are also in line with Khan *et al*. (2015) and Khan *et al.* (2006) who observed that hand weeded plots produced more grain yield, followed by plots treated with plants water extract. Application of 1:3 RWE significantly boosted grain (3622 kg ha^{-1}) yield while decreased in C reduced grain yield and low grain yield (2671 kg ha^{-1}) was obtained with application of 1:5 RWE. Rice water extract applied at emergence resulted in more grain yield (3337 kg ha^{-1}) while low grain yield

(2904 kg ha^{-1}) was noted from RWE applied half at emergence + half at tillering. Significantly higher grain yield (3250 kg ha^{-1}) was produced in plots treated with leaf water extract compared with stem water extract (2978 kg ha^{-1}). The reason of more grain yield might be less or no competition for resources due to controlled of weeds which ultimately contributed to more availability of resources (nutrients, water, solar radiation and soil) that positively enhanced the yield components which led to increased grain yield. Our findings are in conformity with Iqbal *et al*. (2010) who concluded that maximum grain yield was obtained with water extract of sunflower + sorghum + brassica each at 18 L ha^{-1} mixed with half dose of herbicide, followed by 15 L ha^{-1} water extract of the above crop mixed with half dose of herbicide. Our findings are in conformity with Naseem *et al*. (2009) who achieved more grain yield in plots treated with sunflower water extract at pre-emergence + 25 DAS compared with control.

CONCLUSION

It is concluded that rice has the capability to be used for control of weeds. Leaf water extract of rice at 1:3 ratio sprayed at emergence reduced weeds biomass and increased number of tillers m^{-2}, spike length and grain yield of wheat.

Table1. Weeds fresh weight (g m^{-2}) at 80 DAS in wheat as affected by rice extract type, concentration and application time

Concentration Kg : L^{-1}	Application Time	Extract type		Mean
		Stem	Leaf	
1:3		82.97	76.54	79.76 c
1:4		134.04	127.33	130.69 b
1:5		139.53	141.18	140.36 a
	Emergence (E)	114.16	109.82	111.99 c
	Tillering (T)	118.90	113.31	116.11 b
	50% at E+50% at T	123.49	121.92	122.71 a
	Mean	118.85 a	115.02 b	

Control	145.87 a
Rice water extract	116.93 b
Hand weeding	33.90 b
Rice water extract	116.93 a
Herbicide application	23.77 b
Rice water extract	116.93 a

LSD ($P \leq 0.05$) for concentration and application time = 2.33

Means having similar letter(s) with in the same group are statistically similar using LSD test at $P \leq 0.05$.

Table-2. Number of tiller m^{-2} of wheat as affected by rice extract type, concentration and application time

Concentration Kg : L^{-1}	Application Time	Extract type		Mean
		Stem	Leaf	
1:3		328	337	332 a
1:4		291	297	294 b
1:5		282	291	287 b
	Emergence (E)	305	313	309 a
	Tillering (T)	303	312	308 a
	50% at E+50% at T	293	300	296 b
	Mean	300 b	308 a	
Control	266 b			
Rice water extract	304 a			
Hand weeding	337 a			
Rice water extract	304 b			
Herbicide application	351 a			
Rice water extract	304 b			

LSD ($P \leq 0.05$) for concentration and application time = 9
Means having similar letter(s) with in the same group are statistically similar using LSD test at $P \leq 0.05$.

Table-3. Spike length (cm) of wheat as affected by rice extract type, concentration and application time

Concentration Kg : L^{-1}	Application Time	Extract type		Mean
		Stem	Leaf	
1:3		10.11	10.23	10.17 a
1:4		9.88	9.97	9.92 b
1:5		9.74	9.76	9.75 c
	Emergence (E)	9.96	10.03	9.99 a
	Tillering (T)	9.93	9.99	9.96 a
	50% at E+50% at T	9.85	9.94	9.90 b
	Mean	9.91 b	9.99 a	
Control	9.78 b			
Rice water extract	9.95 a			
Hand weeding	10.30 a			
Rice water extract	9.95 b			
Herbicide application	10.35 a			
Rice water extract	9.95 b			

LSD ($P \leq 0.05$) for concentration and application time = 0.044
Means having similar letter(s) with in the same group are statistically similar using LSD test at $P \leq 0.05$.

Table-4. Thousand grains weight (g) of wheat as affected by rice extract type, concentration and application time

Concentration Kg : L^{-1}	Application Time	Extract type		Mean
		Stem	Leaf	
1:3		42.88	43.81	43.34 a
1:4		40.79	41.70	41.24 b
1:5		39.59	39.41	39.50 c
	Emergence (E)	41.66	42.40	42.03 a
	Tillering (T)	40.97	41.58	41.27 ab
	50% at E+50% at T	40.63	40.94	40.79 b
	Mean	41.09	41.64	
Control	37.43 b			
Rice water extract	41.36 a			
Hand weeding	42.55			
Rice water extract	41.36			
Herbicide application	43.78 a			
Rice water extract	41.36 b			

LSD (P ≤ 0.05) for concentration and application time = 0.95
Means having similar letter(s) with in the same group are statistically similar using LSD test at P ≤ 0.05.

Table-5. Grain yield (kg ha^{-1}) of wheat as affected by rice extract type, concentration and application time

Concentration Kg : L^{-1}	Application Time	Extract type		Mean
		Stem	Leaf	
1:3		3475	3768	3622 a
1:4		2904	3197	3051 b
1:5		2556	2786	2671 c
	Emergence (E)	3145	3529	3337 a
	Tillering (T)	2969	3234	3102 ab
	50% at E+50% at T	2821	2988	2904 b
	Mean	2978 b	3250 a	
Control	2417 b			
Rice water extract	3114 a			
Hand weeding	3872 a			
Rice water extract	3114 b			
Herbicide application	4022 a			
Rice water extract	3114 b			

LSD (P ≤ 0.05) for concentration and application time = 256
Means having similar letter(s) with in the same group are statistically similar using LSD test at P ≤ 0.05.

REFERENCES CITED

Afridi, R. A., M. A. Khan, H. Gul and M. K. Daud. 2014. Allelopathic influence of rice extracts on phenology of various crops and weeds. Pak. J. Bot. 46(4): 1211-1215.

Afridi, R.A., and M.A. Khan. 2015. Comparative effect of water extract of *Parthenium hysterophorus, Datura alba, Phragmites australis* and *Oryza sativa* on weeds and wheat. Sains Malaysiana, 44(5): 693-699.

Ahn, J. K. and I. M. Chung. 2000. Allelopathic potential of rice hulls on germination and seedling growth of barnyardgrass. Agron. J. 92: 1162-1167.

Akbar, N., Ehsanullah, K. Jabran and M. A. Ali. 2011. Weed management improves yield and quality of direct seeded rice. Aust. J. Crop Sci. 5(6): 688–694.

Ashraf, M. and M. Akhlaq. 2007. Effects of sorghum leaves, roots and stems water extract, hand weeding and herbicide on weeds suppression and yield of wheat. Sarhad J. Agric. 23(2): 320-327.

Awan, I., I. Wazir, M. Sadiq, M. S. Baloch, I. H. Shah, M. A. Nadim, E. A. Khan, A. A. Khakwani and I. Bakhsh. 2012. Potential application of a crop extract for weed suppression as an alternative for chemical weed control in rice. Pak. J. Weed Sci. Res. 18: 13-20.

Bhadoria, B. P. S. 2011. Allelopathy: A natural way towards weed management. American J. Exp. Agri. 1(1): 7-20.

Cheema, Z. A., M. Iqbal and R. Ahmad. 2002. Response of wheat varieties and some rabi weeds to allelopathic effects of sorghum water extract. Int. J. Agri. Biol. 4(1): 52-55.

Cheema, Z. A., M. Zaman, R. Ahmad and G. Murtaza. 2010. Application of allelopathic water extracts for suppressing the rice weeds. Crop Environ. 1(1): 1-5.

Chon, S. U. and Y. M. Kim. 2004. Herbicidal potential and quantification of suspected allelochemicals from four grass crop extracts. J. Agron. Crop Sci. 190: 145–150.

Chou, C. H., F. J. Chang and H. I. Oka. 1991. Allelopathic potential of wild rice. Taiwania. 36: 201-210.

Elahi, M., Z. A. Cheema, S. M. A. Basra and Q. Ali. 2011. Use of allelopathic extracts of sorghum, sunflower, rice and brassica herbage for weed control in wheat (*Triticum aestivum* L.). Int. J. Agr. Vet. Med. Sci. 5(5): 488-496.

Farooq, M., K. Jabran, H. Rehman and M. Hussain. 2008. Allelopathic effects of rice on seedling development in wheat, oat, barley and berseem. Allelopathy J. 22(2): 385-390.

Farooq, M., K. Jabran, Z. A. Cheema, A. Wahid and K. H. M. Siddique. 2011. The role of allelopathy in agricultural pest management. Pest Manage. Sci. 67(5): 493–506.

Hossain, F., M. Epplin and E. G. Krenzer. 2003. Planting dates influence on dual purpose winter wheat forage yield, grain yield and test weight. Agron. J. 95: 1188-1197.

Hussain, S., S. U. Siddiqui, S. Khalid, A. Jamal, A. Qayyum and Z. Ahmed. 2007. Allelopathic potential of senna on germination and seedling characters of some major cereal crops and their associated grassy weeds. Pak. J. Bot. 39 (4): 1145–1153.

Iqbal, J., F. Karim and S. Hussain. 2010. Response of wheat crop (*Triticum aestivum* L.) and its weeds to allelopathic crop water extracts in combination with reduced herbicide rates. Pak. J. Agri. Sci. 47(3): 309-316.

Jabran, K., Z. A. Cheema, M. Farooq and M. B. Khan. 2011. Fertigation and foliar application of fertilizers alone and in combination with canola extracts enhances yield in wheat crop. Crop Environ. 2(1): 42-45.

Jabran, K., Z. A. Cheema, M. Farooq and M. Hussain. 2010. Lower doses of pendimethalin mixed with allelopathic crop water extracts for weed management in canola (*Brassica napus*). Int. J. Agric. Biol., 12: 335–340.

Jabran, K., Z. A. Cheema, M. Farooq, S. M. A. Basra, M. Hussain and H. Rehman. 2008. Tank mixing of allelopathic crop water extracts with pendimethalin helps in the management of weeds in canola (*Brassica napus*) field. Int. J. Agric. Biol. 10(3): 293–296.

Jafari, L., H. Ghadiri and A. Moradshahi. 2011. Allelopathic Potential of Rice (*Oryza sativa L.*) Cultivarson Barnyard Grass (*Echinochloa crus-galli*). J. Agri. Sci. Tech. 1: 853-864.

Jan, M. T., P. Shah, P. A. Hoolinton, M. J. Khan and Q. Sohail. 2009. Agriculture research: Design and analysis. Deptt. of Agronomy, KPK Agric. Uni. Peshawar, Pakistan.

Kato-Noguchi, H. and T. Ino. 2005. Concentration and release level of momilactone B in the seedlings of eight rice cultivars. J. Plant Physiol. 162(9): 965-969.

Kato-Noguchi, H., T. Ino, N. Sata and S. Yamamura. 2002. Isolation and identification of a potent allelopathic substance in rice root exudates. Physio. Plantarum. 115: 401-405.

Khan, E. A., A. A. Khakwani, M. Munir and Ghazanfarullah. 2015. Effects of allelopathic chemicals extracted from various plant leaves on weed control and wheat crop productivity. Pak. J. Bot. 47(2): 735-740.

Khan, M.A., R.A. Afridi, S. Hashim, A.M. Khattak, Z. Ahmad, F. Wahid and B.S. Chauhan. 2016. Integrated effect of herbicides and allelopathic water extracts on weeds in wheat. Crop Protec. 90: 34-39.

Khan, M.A., R.E. Blackshaw and K.B. Marwat. 2009. Biology of Milk thistle and management options for growers in northwest Pakistan. Weed Biol. Manag. 9(2): 99-105.

Khan, M.A., K. Nawab, Siraj-ud-Din, N. Hussain and B. Gul. 2006. Allelopathic proclivities of tree leaf extracts on seed germination and growth of wheat and wild oats. Pak. J. Weed Sci. Res. 12(4): 265-269.

Khan, R. and M. A. Khan. 2012. Weed control efficiency of bioherbicides and their impact on grain yield of wheat (*Triticum aestivum L.*). Europ. J. Appl. Sci. 4(5): 216-219.

Kim, S. Y., A. V. Madrid, S. T. Park, S. J. Yang, and M. Olofsdotter. 2005. Evaluation of rice allelopathy in hydroponics. Weed Res. 45(1): 74-9.

Macias, F. A., N. Chinchilla, R. M. Varela, and J. M. G. Molinillo. 2006. Bioactive steroids from *Oryza sativa L*. Steroids 71(7): 603-608.

MNFSR. 2014. Ministry of National Food Security and Research, Agricultural Statistics, Economic Wing, Government of Pakistan, Islamabad.

Naseem, M., M. Aslam, M. Ansar and M. Azhar. 2009. Allelopathic effects of sunflower water extract on weed control and wheat productivity. Pak. J. Weed Sci. Res. 15(1): 107-116.

Olofsdotter, M. 2001. Rice: A step toward use of allelopathy. Agron. J. 93(1): 03-08.

Razzaq, A., Z. A. Cheema, K. Jabran, M. Farooq, A. Khaliq, G. Haider and S. M. A. Basra. 2010. Weed management in wheat through combination of allelopathic water extracts with reduced doses of herbicides. Pak. J. Weed Sci. Res. 16 (3): 247–256.

Rehman, A., Z. A. Cheema, A. Khaliq, M. Arshad and S. Mohsan. 2010. Application of sorghum, sunflower and rice water extract combinations helps in reducing herbicide dose for weed management in rice. Int. J. Agric. Biol. 12(6): 901–906.

Saleem, M. A. M. and M. O. A. Fawusi. 1993. A note on the effects of tropical weed decomposition on seed germination and seedling growth of some agricultural crops. Agri. Eco. Systems Environ. 10: 347-352.

Santos, B. M. 2009. Drip-applied metam potassium and herbicides as methyl bromide alternatives for Cyperus control in tomato. Crop Prot. 28(1): 68–71.