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PERFORMANCE OF SOYBEAN AGAINST ALLELOPATHIC LEAF AQUEOUS EXTRACTS AND SOIL INCORPORATED RESIDUES

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Abstract

Allelopathy is the study of plant exudates with their supplementary or antagonistic effect towards other plant species. Wise use of Allelopathy and its further investigations may result new and effective chemicals which may have positive effect on crop stands in one way or other. The present investigation is aimed to probe the allelopathic effect of Rice and Mustard on Soybean. The study was carried out in 2018 at the Islamia University of Bahawalpur in laboratory as well as in wire-house. In the laboratory phase of this experiment, overall sprouting and growth pattern of Soybean was observed against different concentrations of mentioned plant species. Yield and quality attributes were tested in wire-house conditions via soil incorporated residues of Rice and Mustard (which were left for decomposition for different time interval). Results from the laboratory bioassay revealed that higher concentrations of rice i.e. 3, 4 and 5% while all tested concentrations of mustard i.e. 1, 2, 3, 4 and 5% significantly reduced the germination and seedling growth of soybean when equated to control. Whereas lower concentration of rice i.e. 1 and 2% produced similar results to the control. Results from the wire-house phase of the study unveiled that 1% and 2% of rice augmented the plant height, numbers of pods per plant, numbers of grains per pod, 1000 grain weight, chlorophyll content, leaf area index, crop growth rate, biological yield and grain yield hill^{-1} of Soybean. Other concentrations i.e. 3, 4 and 5% of rice and all the tested concentrations of mustard i.e. 1, 2, 3, 4 and 5% reduced the mentioned parameters significantly. Based upon the results it is concluded that lower aqueous extract concentrations of rice (1 and 2%) increase the growth and yield of soybean and may further be used in investigations related to this crop.

Key words: Allelopathy, Rice, Mustard, Plant exudates, Germination, Crop growth rate.

Introduction

Soybean (*Glycine max* L.) has been designated at the top of the list among oilseed crops of the world, being a most nutritious commodity and cultivated worldwide with the principal share in edible oil production of the world. It is rich in protein contents (above 40%), unsaturated and saturated fatty acids (85% and 16% respectively), carbohydrates (29%), moisture (5-6%), ash (5%) and contains an extensive extent of nutrients like P, Fe, Ca and vitamins (Alghamdi *et al*., 2018). Soybean crop enjoys privilege over other oilseed crops like sunflower and canola because of its outstanding agro-environmental efficiency, nutritional values and health benefits (Dekamin & Barmaki, 2018). However, this highly nutritious crop has gained little importance among farmers in Pakistan since its introduction in the country in 1970. In 2016-17, Pakistan has produced 0.426 million tonnes of edible oil only, which contributed 14 % only to the country's demand (3.726 million tonnes). Resultantly, US$ 2.710 billion were disbursed as the edible oil import bill to meet the requirement of the population (Govt. of Pakistan, 2016-17).

Weeds pose a serious threat to the crop plants as these strive for inputs like water and nutrients. It is observed that weed-induced yield losses are much higher compared with pests and diseases in cereals, pulses and oilseed crops (Khan *et al*., 2015: Gharde *et al*., 2018). In Pakistan, Rabi crops are distinctly prone to weeds like *Chenopodium album* L., *Convolvulus arvensis* L., *Avena fatua* L. and *Phalaris minor* Retz., which result in major losses to yield and quality. On the other hand, inopportune, habitual, non-judicious and unwise use of herbicides not only risk the environment and human health but also leads to crop injury and induces herbicidal resistance in weeds (Jabran *et al*., 2011; Defarge *et al*., 2018). To cope with this, scientists are using phytochemicals named allelochemicals, as bio-herbicides. The chemicals, produced by plant species, are classified as organic acids, lactones, fatty acids, phenolics, tannins, quinines, terpenoids and steroids (Raghuveer *et al*., 2015). These putative allelochemicals, released by a plant suppress the growth of other plants via being phytotoxic for them actually and potentially. Researchers have screened out many plant species i.e. rice (Anuar & Ahmad, 2015), brown mustard (Khaliq *et al*., 2013), canola (Haddadchi & Gerivani, 2012), sorghum (Arif *et al*., 2015), mulberry (Haq *et al*., 2010) and moringa (Soliman *et al*., 2017) whose aqueous extracts can be utilized as bio-herbicides. The evaluation of allelopathic behavior and capacity of any plant involve bioassays of extracts and soil incorporated residues determining the seed germination and seedling growth of the target species (Baličević *et al*., 2014). It is well-known that p-hydroxybenzoic acid, vanillic acid, p-coumeric acid and ferulic acid are present in rice (Hao *et al*., 2010; Heidarzade *et al*., 2010; Linh *et al*., 2017) while glucosinolates and its breakdown products like isothiocyanates (i.e. allyl-isothiocyanate, Benzyl-isothiocyanate, ionic-thiocyanate) also produced by brassica species which causes a significant reduction in seedling growth of target species (Yang & Quiros, 2010;

Matloob *et al*., 2010; Haddadchi and Gerivani, 2012; Al-Sherif *et al*., 2013). These allelopathic chemicals alter the growth pattern of weeds via deterring the sprouting and development; it may also harm crop plants. Therefore, a deeper understanding of the behavior of allelopathic chemicals must be initially estimated against certain crop plants for any deleterious results in terms of growth and yield. However, the information regarding the use of aqueous extracts of allelopathic chemicals from rice and mustard and to suppress weeds growth is scarce.

Thus, the present study is being carried out with the hypothesis that lower aqueous extract concentrations of rice and mustard have no antagonistic effect on the germination, growth and yield of soybean. If accepted from the results, this investigation may bring a chance to explore the effect of these plant exudates against the weeds of soybean.

Materials and Methods

This study was conducted in the laboratory and wire-house of University College of Agriculture and Environmental Sciences (UCA & ES), The Islamia University of Bahawalpur (Pakistan) with 29.3788° N and 71.7652° E in year 18. The young leaves of Rice and Brassica were obtained randomly from well-nourished and mature plants at Agronomic Research Area. The seeds of soybean were provided by the National Agricultural Research Council (NARC) Islamabad, Pakistan. Both phases of the experiment were laid out in Complete Randomized Design (CDR) using three replicates.

Laboratory bioassay: Before the start of the laboratory study, recently collected fresh leaves of rice and brassica were washed with distilled water to remove the dust particles. These leaves were later dried with blotting paper, powdered, to prepare 10% stock solution of each species, 10g of crushed dry material was mixed in 100 ml of distilled water for 36 hours at 25 C (Shafique *et al*., 2005). The solution was filtered and further diluted to obtain 1, 2, 3, 4 and 5% using equivalent dilution technique. Randomly selected 10 healthy seeds of soybean were sterilized with 5% sodium hypochlorite solution for two minutes. These seeds were sown on filter paper (Whattman no. 10) moistened with aqueous extracts (4 ml) of rice and mustard in sterilized petri dishes (9 cm) and covered (Narwal *et al*., 2007). The distilled water was used in control treatments. The data regarding final germination (%), mean germination time (days) and promptness index was recorded by following the standards of International seed testing association, sis of, Seedling length (cm) was estimated by using measuring rod while the electrical weighing balance (AND-3000, Japan) was used to measure seedling fresh weight (g) and seedling dry weight (g).

Wire-house bioassay: For the phase of the experiment to be conducted in wire-house, the collected leaves of evaluating species were first washed then dried and chopped into 2 cm pieces prior to incorporate in pots containing 5 kg soil. This chopped material was left to be decomposed for the different number of days i.e., 0, 7, 14, 21 and 28 before sowing. Seeds were sown at the same time and one plant of soybean was maintained per hill. Pots without plant residues were considered as a control treatment. The data was collected during the study and evaluated for plant height (cm), numbers of pods per plant, numbers of grain per pod, 1000 grain weight (g), Leaf area index (LAI), Crop growth rate (g m^{-2} d^{-1}), Economic yield/Grain yield (g/ hill), Crude protein (%) and Oil percentage.

Seedling stand establishment: From the laboratory phase, final germination was calculated by using the formula:

$$\text{Final germination percentage} = \frac{\text{Final number of seedling emerged}}{\text{Total number of seeds sown}} \times 100$$

Equation of Ellis and Roberts (1981) was used to compute the mean germination time (MGT) where

$$MET = \frac{\sum Dn}{\sum n}$$

where n is the number of germinated seeds on day D and D is the total number of days counted from the beginning of germination.

Emergence index (EI) was measured according to the handbook of the Association of Official Seed Analysts (1983) by the implementing formulae:

$$Emergence\ Index = \frac{\text{Number of germinated seeds}}{\text{Days of first count}} \pm - - - + \frac{\text{Number of germinated seeds}}{\text{Days of ultimate count}} \text{ Promptness}$$

Determination of agronomic attributes: The seedling length was measured from the tip of the root to the terminal point of the shoot with help of measuring rod and then the average was worked out. Seedling fresh weight was determined immediately after harvesting while dry weight was taken after drying at 70°C for 72 hours by using electrical weighing balance.

In the case of wire-house study leaf area index was calculated from the data of leaf area per plant measured at 30, 60, 90 and 120 DAS by using the formula given by Hunt (1978).

LAI = Leaf area $plant^{-1}$/ Land area $plant^{-1}$

Crop growth rate (CGR) was calculated by following the formula of Duncan *et al*., (1978).

$$CGR= (W_2-W_1) / (t_2-t_1)$$

where W_2 and W_1 represents total dry matter production (g) at times t_2 and t_1 respectively Plant height at maturity was measured with the help of a meter rod from base to the tip of shoot plant from each replicate and then averaged for the treatment concerned.

Quantification of yield and yield contributing traits: Total pods from each plant were carefully counted and then averaged. Grain sample from each plant was obtained, weighed and worked for 1000 grain weight. All the pods from each hill/ plant were obtained, dried under the sun, shelled and weighed using electrical weighing balance. The recorded data was manipulated for economic yield/ grain yield for that particular treatment. Root nodules were count by calculation method.

Determination of Quality traits: Crude protein contents (%) were computed by multiplying N content of the Soybean seeds which was determined by micro Kjeldahl assay, by a conversion factor of 6.25 (Jackson, 1973). The oil content of Soybean seeds was extracted by the Folch method (Folch *et al*., 1957) by using chloroform and methanol in 2:1 ratio. The extractant was removed by heating and oil obtained was expressed in percentage. Moisture percentage was calculated using an oven drying method.

Statistical analysis

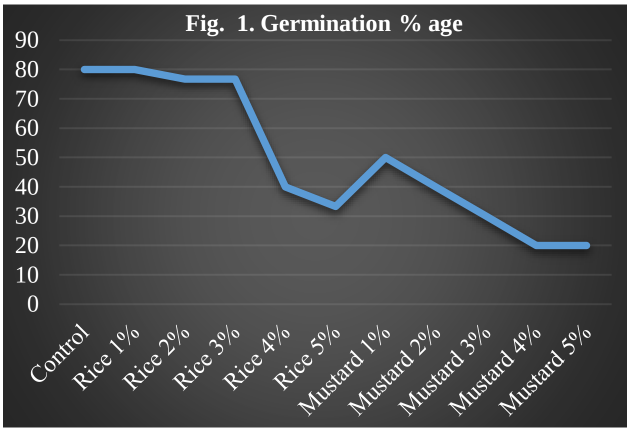
Graphical representation of seedling growth data was made and standard error was computed using Microsoft Excel Program (Microsoft Corporation, Los Angeles, CA, USA) for comparison of treatments. Data collected was analyzed statistically by using Fisher‘s Analysis of Variance Techniques and Least Significantly Difference (LSD) test at 5% probability level was applied to compare the treatment means (Steel and Torrie, 1984) using software Statistix 10 developed by Analytical Software 2015 Miller Landing Rd Tallahasee FL 32312 USA.

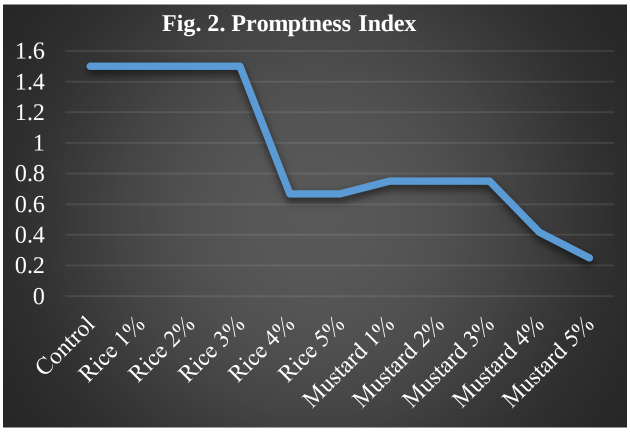
Results and Discussion

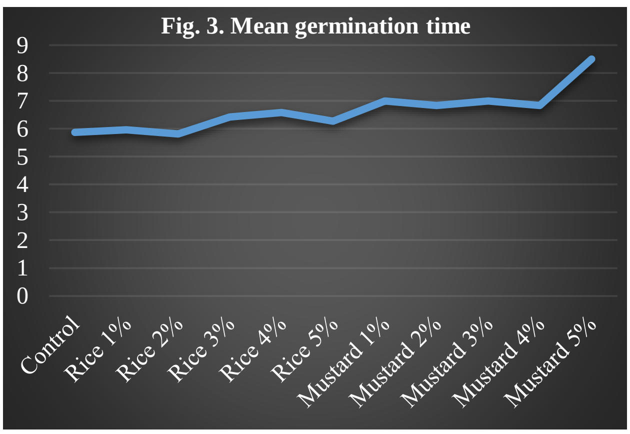
Germination and seedling establishment in laboratory bioassay: Data showed the effects of leaf aqueous extract of rice and mustard, in different concentration on germination of soybean (Fig. 1). It was observed that all treatments had significantly reduced germination percentage of soybean except lower concentrations of rice (1%, 2% and 3%) who behaved like untreated control. Highest germination of soybean seeds (80%) was observed in control while mustard (4 and 5%) showed minimum values for germination (20%) by significantly restricting soybean emergence. While studying promptness index (PI), it was observed that lower concentrations of rice (1%, 2% and 3%) were statistically at par and behaved like control) while all other concentrations of rice and mustard showed a significant decrease in PI (Fig. 2). Highest PI (1.75) was observed in case of control and lower concentrations of rice (1%, 2% and 3%) while lowest (0.2500), which was 14.29% of control, was observed in case of 5% leaf aqueous extracts of mustard. As compared to control, minimum mean emergence time (5.8095 days) for soybean seeds was noted for 2% of rice extract while the lowest concentration of rice took a bit higher time for emergence over control. All other concentrations of the tested species had a significant increase in MET of the crop and this increase was found growing with extending concentrations. Hence, soybean seeds illustrated maximum MET (8.5 days) when subjected to the highest concentration (5%) of Mustard (Fig. 3).

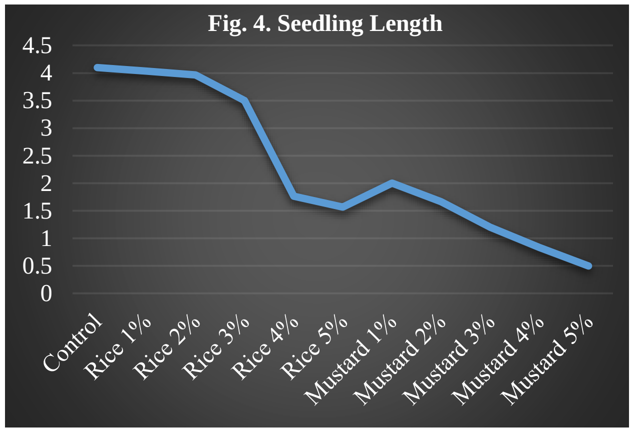
Seedling growth and allied attributes from laboratory bioassay: Likewise, aqueous extracts of rice and mustard had demonstrated a significant effect on soybean seedling length (Fig. 4). It is cleared from data that lower concentrations of rice (1% and 2%) produced seedling length i.e. 4.03 and 3.96 cm respectively, which were at PAR with untreated control (4.1 cm). All other treatments of rice along with all concentrations (1% to 5%) of mustard significantly restricted plant growth in terms of seedling length. Lowest seedling length (0.50 cm) was found when soybean was treated with the highest concentration (5%) of mustard. Similar to seedling length, lower concentrations of rice (1% and 2%) had a non-significant effect on the seedling fresh and dry weight of soybean as compared to control. All other concentrations of rice and all the tested concentrations (1% to 5%) of mustard affected the seedling fresh weight and dry weight negatively and significantly (Figs. 5 and 6). Maximum seedling fresh weight (4.51 g) and dry weight (1.127 g) were observed in case of control while lowest seedling fresh (0.55 g) and dry weight (0.137 g) were expressed by soybean when subjected to 5% mustard leaf extract.

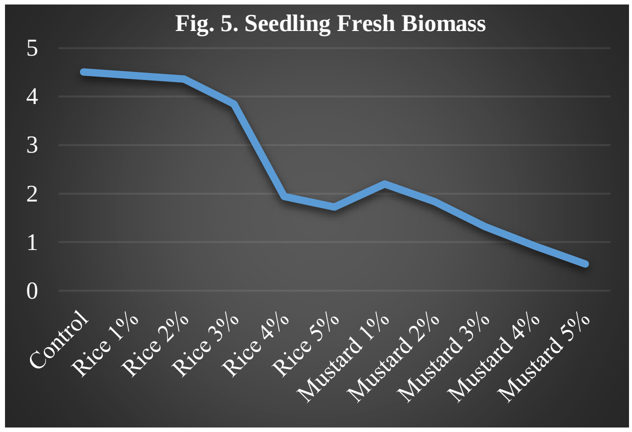
Growth and yield attributes from the wire-house bioassay: Allelopathic effect of rice and mustard was observed on growth and yield attributes of soybean in this study. It was evident from data that lower concentrations of rice (1%) had augmented while 2% had at PAR with control effect on growth and yield of soybean (Table 1). All the tested concentrations of mustard had a strong inhibitory effect on the growth and yield of this valuable oilseed crop (Table 2). When treated with rice, Soybean showed maximum plant height (97 cm), No. of pods/ plant (116.33), 1000 grain weight (102.80 gm), biological yield hill^{-1} (147.67 gm), crop growth rate (4.6444 gm^{-2}d^{-2}) and grain yield hill^{-1} (35.367 gm) in case of 1% leaf residues which were soil incorporated and left for decomposition for 7 days before sowing. Maximum No. of grain/pod (2.9682), chlorophyll content (3.7194) and LAI (2.4484) was observed in the case of 1% leaf residues where sowing was done just after incorporation. All of the mentioned traits were found statistically at PAR with control at 2% concentration of rice residues, irrespective of the decomposition time. 3, 4 and 5% concentrations of rice residues inhibited all the studied parameters negatively and significantly. Lowest plant height (48 cm), No. of pods/ plant (57.57), No. of grain/pod (2.6346), 1000 grain weight (50.87 gm), biological yield hill^{-1} (73.17 gm), chlorophyll content (1.7286), LAI (1.2031), crop growth rate (2.9333 gm^{-2}d^{-2}) and grain yield hill^{-1} (7.773 gm) was observed in case of 5% soil incorporated leaf residues.

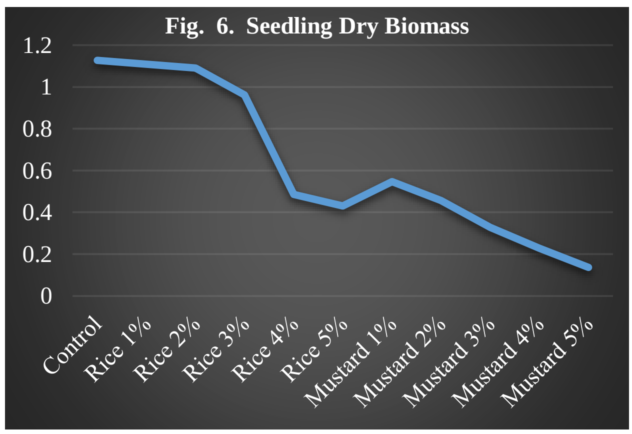












Effect of rice and mustrad on seed germination, stand establishment and seedling growth of soybean.

Against mustard, maximum plant height (87.33 cm), No. of pods/ plant (105), No. of grain/pod (2.8123), 1000 grain weight (92.77 gm), biological yield hill^{-1} (132.92 gm), chlorophyll content (3.1211), LAI (2.0546), crop growth rate (4.1556 gm^{-2}d^{-2}) and grain yield hill^{-1} (27.400 gm) was observed in case of untreated control. All the tested concentrations of mustard, irrespective of the decomposition times, inhibited the growth and yield parameters significantly. Lowest plant height (30.33 cm), No. of pods/ plant (36.33), No. of grain/pod (2.5413), 1000 grain weight (31.96 gm), biological yield hill^{-1} (45.92 gm), crop growth rate (2.2000 gm^{-2}d^{-2}) and grain yield hill^{-1} (3.167 gm) was found in case of 5% soil incorporated leaf residues while lowest chlorophyll content (2.0920) and LAI (1.3772) was observed in case of 1% soil incorporated leaf residues.

Quality attributes from the wire-house bioassay: Quality attributes i.e. oil and crude protein percentage were not affected significantly by rice and mustard except few treatments (Table 3). Excluding 3% of rice leaf residues (which were left for decomposition for 28 days before sowing) along with 1% and 2% of mustard leaf residues (which were left for decomposition for 21 and 28 days before sowing, respectively), all the residue treatments have statistically at PAR results with control. With minor augmentation, most of the rice residue treatments were found with a positive effect on oil and crude protein percentage of soybean. Maximum oil and crude protein % age (20.857 and 38.017) was observed when treated with 2% rice residues (which were left for decomposition for 28 days before sowing) while lowest oil and crude protein % age was observed when treated with 3% rice residues (which were left for decomposition for 28 days prior to sowing). Contrary to rice, most of the mustard treatments inhibited (but non-significantly) the oil and crude protein percentage of soybean. Maximum oil and crude protein % age (20.770 and 37.930) was observed when treated with 5% mustard residues (which were left for decomposition for 14 days before sowing) while lowest oil and crude protein % age was observed when treated with 1% mustard residues (which were left for decomposition for 21 days before sowing).

Discussion

Maximum reduction by mustard is possibly due to glucosinolates and its breakdown products like isothiocyanates (i.e., allyl-isothiocyanate, Benzyl-isothiocyanate, ionic-thiocyanate) which are reported to reduce seed germination and plant growth via suppressing the activity of peroxidase (POD), catalase (CAT), superoxide dismutase (SOD), polyphenoloxidase (PPO) enzymes, reducing the protein content of hypocotyl and radicle along with lipid peroxidation (MDA) of the radicle (Haddadchi & Gerivani, 2012). The results of this study agreed with those reported by Oskouei *et al*., (2012) who revealed that soybean is sensitive to the glucosinolates present in rapeseed which inhibited seedling percentage, seedling length and weight vigor indices when soybean is treated with rapeseed aqueous extracts.

The allelopathic chemicals present in rice like phenolic acid i.e. ferulic acid and *p*-coumaric acid, indoles, terpenes, diterpenoids, flavones and Momilactone A& B are primarily inhibiting in nature via limiting the water utilization (ferulic acid), decreasing cell division at mitosis level (*p*-coumaric acid), inhibiting the energy metabolism and mitochondrial oxygen (terpenes, diterpenoids and their derivatives) but the suppression due to these chemicals is concentration-dependent (Einhellig, 1986; Oudhia *et al*., 1988; Einhellig and Rasmussen, 1993; Anwar *et al*., 2003; Chon *et al*., 2003; Farooq, 2008; Cheema *et al*., 2012; Narwal, 2012; Ambika, 2013). Khan *et al*., (2011) and Masum *et al*., (2012) also found similar results that soybean is tolerant to the allelopathic aqueous extracts of *Parthenium hysterophorus* L. and *Chromolaena odorata* L. at lower doses only. Khaliq *et al*., (2010) also found that soil incorporated residues of sorghum, sunflower and rice suppressed the density and dry weight of the weeds while augmented the yield and its related parameters for maize.

Table 1. Effect of rice on growth of soybean.

Conc.	D.T.	Plant height	NOP/ Plant	Grains/ Pod	1000 grain weight	Biological yield	Chlorophyll content	Leaf area index	Crop growth rate	Grain yield
Control		87.333 bc	105.00 bc	2.8123 bcd	92.78 bc	132.92 bc	3.1211 e	2.0546 e	4.1556 b	27.400 cd
	0	96.667 a	116.00 a	2.9682 a	102.30 a	144.08 a	3.7194 a	2.4484 a	4.4000 ab	35.307 a
	7	97.000 a	116.33 a	2.9628 a	102.80 a	147.67 a	3.6268 abc	2.3875 abc	4.6444 a	35.367 a
1	14	95.333 a	115.00 a	2.9771 a	101.33 a	145.17 a	3.6197 abc	2.3828 abc	4.4000 ab	34.700 a
	21	95.000 a	114.00 a	2.9502 a	100.67 a	144.67 a	3.5462 bcd	2.3344 bcd	4.6444 a	33.900 ab
	28	96.667 a	116.00 a	2.9655 a	102.50 a	147.17 a	3.6305 ab	2.3899 ab	4.4000 ab	35.267 a
	0	96.333 a	115.33 a	2.8496 b	102.13 a	147.58 a	3.4601 cd	2.2777 cd	4.4000 ab	33.733 ab
	7	94.333 a	113.00 a	2.8524 b	99.93 a	143.67 a	3.3967 d	2.2360 d	4.4000 ab	32.220 b
2	14	89.667 b	107.67 b	2.8391 bc	94.97 b	136.50 b	3.2260 e	2.1236 e	4.4000 ab	29.067 c
	21	86.333 bc	103.67 bc	2.8521 b	91.43 bc	131.50 bc	3.1219 e	2.0551 e	4.4000 ab	27.100 cd
	28	85.000 c	102.33 c	2.8501 b	90.10 c	129.42 c	3.0754 e	2.0245 e	4.4000 ab	26.300 d
	0	65.000 de	78.00 de	2.7481 def	68.97 d	99.00 de	2.4904 fg	1.6394 fg	3.6667 c	14.800 ef
	7	65.000 de	78.33 d	2.7575 def	68.83 de	99.00 de	2.4991 f	1.6451 f	3.6667 c	14.860 ef
3	14	65.667 d	79.00 d	2.7553 def	69.60 d	99.83 d	2.5245 f	1.6618 f	3.6667 c	15.133 e
	21	65.333 d	78.67 d	2.7673 cde	69.30 d	99.63 d	2.5294 f	1.6651 f	3.6667 c	15.133 e
	28	65.000 de	78.33 d	2.7407 def	68.87 de	99.58 d	2.4800 fg	1.6236 fg	3.6667 c	14.833 ef
	0	61.667 ef	74.00 ef	2.7028 efgh	65.37 ef	93.83 ef	2.3259 gh	1.5311 gh	3.6667 c	13.100 efg
	7	58.333 fgh	70.00 fgh	2.6904 fgh	62.13 fgh	88.83 fgh	2.2056 hij	1.4525 hij	2.9333 d	11.767 ghi
4	14	60.667 fg	73.33 fg	2.7228 efg	64.00 fg	92.42 fg	2.2905 hi	1.5078 hi	2.9333 d	12.700 fgh
	21	55.333 gh	66.67 hij	2.6951 efgh	58.63 hi	84.17 hij	2.0913 j	1.3767 j	2.9333 d	10.567 hi
	28	56.333 hij	68.00 hij	2.6909 fgh	59.67 hi	85.33 hij	2.1372 ij	1.4069 ij	2.9333 d	10.953 ghi
	0	54.667 ij	65.67 ij	2.6499 gh	57.90 i	83.25 j	2.0911 j	1.3765 j	2.9333 d	10.100 i
	7	54.667 ij	65.67 ij	2.6346 h	57.97 i	83.33 ij	2.0756 j	1.3663 j	2.9333 d	10.033 ij
5	14	58.000 ghi	69.67 ghi	2.6412 h	61.67 gh	88.50 ghi	2.2141 hij	1.4575 hij	3.1778 d	11.367 ghi
	21	48.000 k	57.57 k	2.6410 h	50.87 j	73.17 k	1.8276 k	1.2031 k	2.9333 d	7.773 j
	28	54.333 j	65.33 i	2.6529 gh	57.83 i	82.83 j	2.1112 j	1.3898 j	2.9333 d	10.167 i
LSD value		3.4164	4.0281	0.0745	3.5782	5.2422	0.1691	0.1113	0.4167	2.2865

Table 2. Effect of mustard on growth of Soybean.

Conc.	D.T.	Plant height	NOP/ Plant	Grains/ Pod	1000 grain weight	Biological yield	Chlorophyll content	Leaf area index	Crop growth rate	Grain yield
Control		87.333 a	105.00 a	2.8123 a	92.777 a	132.92 a	3.1211 a	2.0546 a	4.1556 a	27.400 a
	0	51.333 b	61.67 b	2.7512 a	54.433 b	78.25 b	2.3643 cdefgh	1.5564 cdefgh	3.6667 b	9.267 b
	7	49.667 bc	59.67 bc	2.7541 a	52.667 bc	75.67 bc	2.3061 fghi	1.5181 fghi	3.6667 b	8.733 bc
1	14	46.667 def	56.00 de	2.7560 a	49.400 def	71.33 def	2.1587 ij	1.4210 ij	3.6667 b	7.700 bcdef
	21	48.333 cd	58.33 cd	2.7543 a	51.300 cd	73.50 cd	2.2589 ghij	1.4870 ghij	3.6667 b	8.300 bcd
	28	44.667 fg	54.33 e	2.7548 a	47.467 fg	68.00 fg	2.0920 j	1.3772 j	3.6667 b	7.133 cdefg
	0	48.000 cd	57.67 cd	2.6473 b	50.700 cde	72.92 cde	2.3665 cdefgh	1.5579 cdefgh	3.6667 b	7.767 bcde
	7	45.333 ef	54.00 e	2.6419 b	48.133 ef	68.92 ef	2.2176 hij	1.4598 hij	3.6667 b	6.900 defg
2	14	47.667 cde	57.33 cd	2.6570 b	50.633 cde	72.42 cde	2.3830 cdefgh	1.5687 cdefgh	3.6667 b	7.767 bcde
	21	48.000 cd	57.67 cd	2.6530 b	50.933 cd	72.33 cde	2.4681 cdef	1.6247 cdef	3.6667 b	8.033 bcd
	28	48.000 cd	57.67 cd	2.6474 b	50.900 cd	73.17 cd	2.3682 cdefgh	1.5590 cdefgh	3.6667 b	7.800 bcde
	0	41.667 h	50.33 f	2.6357 b	44.267 h	63.75 h	2.2742 ghi	1.4971 ghi	3.4222 bc	5.800 ghijk
	7	42.333 gh	51.00 f	2.6402 b	44.867 gh	64.58 gh	2.3564 defgh	1.5512 defgh	2.9333 d	6.093 fghi
3	14	42.000 h	50.67 f	2.6316 bc	44.300 h	63.08 h	2.3497 defgh	1.5468 defgh	3.4222 bc	5.933 ghij
	21	42.000 h	50.33 f	2.6550 b	44.533 h	63.58 h	2.5051 bcd	1.6491 bcd	3.6667 b	6.367 efgh
	28	42.000 h	50.67 f	2.6381 b	44.570 h	63.67 h	2.3564 defgh	1.5500 defgh	3.6667 b	6.000 ghij
	0	37.667 i	45.33 g	2.6103 bcd	39.900 i	57.42 i	2.4046 cdefg	1.5829 cdefg	3.1778 cd	4.833 hijkl
	7	37.000 i	44.33 gh	2.6014 bcd	39.167 i	56.33 i	2.3318 efgh	1.5350 efgh	2.9333 d	4.600 ijklm
4	14	35.667 i	42.33 h	2.6224 bc	37.867 i	54.42 i	2.2220 hij	1.4627 hij	2.9333 d	4.233 klm
	21	37.000 i	44.33 gh	2.6090 bcd	39.233 i	56.42 i	2.3281 efghi	1.5326 efghi	2.9333 d	4.600 ijklm
	28	36.333 i	44.00 gh	2.6061 bcd	38.500 i	55.42 i	2.2854 ghi	1.5044 ghi	2.9333 d	4.433 jklm
	0	30.667 j	37.33 i	2.5448 d	32.567 j	46.67 j	2.5180 bcd	1.6576 bcd	2.2000 e	3.233 lm
	7	30.667 j	36.67 i	2.5636 cd	32.600 j	46.50 j	2.5271 bc	1.6636 bc	2.2000 e	3.233 lm
5	14	30.333 j	36.33 i	2.5506 d	31.967 j	45.92 j	2.5055 bcd	1.6493 bcd	2.2000 e	3.167 m
	21	30.667 j	36.33 i	2.5413 d	32.700 j	46.83 j	2.4831 bcde	1.6346 bcde	2.2000 e	3.200 lm
	28	32.000 j	38.67 i	2.5602 cd	34.100 j	48.75 j	2.6517 b	1.7456 b	2.2000 e	3.567 lm
LSD		2.5743	2.9204	0.0714	2.6265	4.0407	0.1704	0.1122	0.3918	1.6461

Table 3. Effect of rice and mustard on quality of soybean.

Conc.	D.T.	Rice		Mustard	
		Oil %	Crude protein %	Oil %	Crude protein %
Control		20.737 a	37.897 a	20.737 abc	37.897 abc
1	0	20.847 a	38.007 a	20.613 abcde	37.773 abcde
	7	20.647 a	37.807 a	20.633 abcde	37.793 abcde
	14	20.837 a	37.997 a	20.600 abcde	37.760 abcde
	21	20.327 a	37.487 a	20.467 e	37.627 e
	28	20.847 a	38.007 a	20.613 abcde	37.773 abcde
2	0	20.847 a	38.007 a	20.567 abcde	37.727 abcde
	7	20.857 a	38.017 a	20.520 cde	37.680 cde
	14	20.317 a	37.477 a	20.713 abcd	37.873 abcde
	21	20.773 a	37.933 a	20.693 abcde	37.817 abcde
	28	20.843 a	38.003 a	20.490 de	37.650 de
3	0	20.510 a	37.670 a	20.600 abcde	37.760 abcde
	7	20.513 a	37.673 a	20.533 bcde	37.693 bcde
	14	20.687 a	37.847 a	20.533 bcde	37.693 bcde
	21	20.680 a	37.840 a	20.700 abcd	37.860 abcd
	28	14.520 b	31.680 b	20.533 bcde	37.693 bcde
4	0	20.533 a	37.693 a	20.567 abcde	37.727 abcde
	7	20.340 a	37.500 a	20.567 abcde	37.727 abcde
	14	20.573 a	37.733 a	20.567 abcde	37.727 abcde
	21	20.373 a	37.533 a	20.533 bcde	37.693 bcde
	28	20.790 a	37.950 a	20.600 abcde	37.760 abcde
5	0	20.340 a	37.500 a	20.693 abcde	37.853 abcde
	7	20.563 a	37.723 a	20.693 abcde	37.853 abcde
	14	20.460 a	37.620 a	20.770 a	37.930 a
	21	20.717 a	37.877 a	20.747 abc	37.907 abc
	28	20.580 a	37.740 a	20.753 ab	37.913 ab
LSD		2.4097	2.4197	0.2295	0.2294

Conclusion

Soybean *(Glycine max* L.) is resistant in terms of germination, growth and yield against the lower concentrations of aqueous extracts and residues of rice (*O. sativa* L.) So, aqueous extract of rice may be tested against the weeds of soybean. If lower concentrations of aqueous extracts of rice suppress the germination and growth of weeds, it may be used in soybean fields as bio-herbicide.

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