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Response of Aqueous Extract of Botanical Herbicides on the Performance of Transplanted Rice during Boro Season

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Authors' contributions

This work was carried out in collaboration among all authors. Authors CK and RG designed the study. Authors CK and PN performed the statistical analysis, wrote the protocol. Author PN wrote the first draft of the manuscript. Authors CK and DM managed the analyses of the study. Author AG managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted in humid sub-tropics of West Bengal at the Instructional Farm, Jaguli of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, India during 2016-17 to study some growth and yield parameters, also the economic advantages of various weed management treatments of summer transplanted paddy. The experiment was conducted with 8 treatments [T_1- & T_2 - Pre–emergence (PE) sole aqueous organic botanical extracts (AOBE) of *Tectona grandis* & *Bambusa vulgaris respectively* @ 100 mL/L water*;* T_3 - PE sole synthetic organic chemical herbicides (SOCH) *Pretilachlor* 30.7 EC @ 500 g/ha;T_4 – PE mixture of AOBE of *Bambusa vulgaris* & *Tectona grandis* @ 100 mL/L water; T_5 – PE mixture of AOBE of *Tectona grandis* @ 100 mL/L water & SOCH *Pretilachlor* 30.7 EC @ 500 g/ha; T_6 -PE mixture of AOBE *Bambusa vulgaris* of @ 100 mL/L water & SOCH *Pretilachlor* 30.7 EC @ 500 g/ha; T_7 – Hand weeding (HW) at 25 & 45 days after transplanting (DAT) and T_8 – Weedy check with three replications following randomised block design (RBD). The results revealed that the treatments T_7 recorded the maximum biological

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yield (grain – 4.76 & straw 5.95 t/ha) and was statistically at par with the mixture of botanical and chemical treatments (T_5 - 4.35 and 5.52 t/ha respectively) and T_6 - 4.42 and 5.54 t/ha, respectively). The T_6 recorded the highest benefit – cost ratio (BCR) value of 2.41 followed by T_5 with 2.38. But in case of treatment T_7, maximum cost of cultivation was incurred over all treatments due to higher expenditure on labour wages for that reason BCR was comparatively lower (2.02) and the lowest BCR was obtained against weedy check (T_8) 1.85. Therefore, considering the crop growth, rice productivity, economics and farmers" easy availability the mixture treatments of AOBE *Bamboosa vulgaris* or *Tectona grandis* with SOCH Pretilachlor may be the best option and is an alternative to traditional HW treatment for increasing rice productivity through ecosafe weed management in transplanted paddy.

Keywords: Summer rice; botanical herbicide; crop growth; grain yield.

1. INTRODUCTION

Among cereals rice (*Oryza sativa* L.) is the most important and extensively grown in tropical and subtropical regions of the world, and is staple food for more than 60 per cent of the world population. Rice occupies a pivotal place in Indian agriculture as it is the staple food for more than 70 % of the population and a source of livelihood for about 120 to 150 million rural home holds. In India, rice is cultivated round the year in one or the other part of the country, in diverse ecologies spread over 43.8 M ha [1] with a production of 85.3 million tonnes of rice and the average productivity being 2.96 t ha^{-1}. However, rice productivity in India is very low (1,710 kg ha^{-1}). To feed this estimated 1.6 billion population of India by 2050 calls for stepping up the current production of 106 mt of milled rice to 140 mt [2]. There are several reasons for low productivity of rice and out of that losses caused due to weeds are one of the most important. Weeds are most severe and widespread biological constraints to crop production. The yield losses due to uncontrolled weed growth in lowland and upland rice ranges from 12 to 81 per cent [3,4]. Weeds also may directly reduce profits by hindering harvest operations, lowering crop quality, and weeds left uncontrolled may harbour insects and diseases and produce seed or rootstocks which infest the field and attack future crops [5]. Rice and rice weeds have similar requirements for growth and development. When nutrients, light, moisture, space etc. growth requirement resources are not optimum for crop and weeds then competition starts between them. Weeds by nature of their high adaptability and faster growth dominate the crop habitat, utilize all resources and reduce the yield potential of the crop.

Among the different methods of weeds management, physical (manual like hand weeding) is eco-safe but need more cost while mechanical weeding is eco-safe, lesser cost but unable to control weeds of intra row and damaging plant roots. Moreover the devices (paddy weeder, wheel hoe *etc.*) are not available in the interior rural areas. Chemical method is lesser costly and controlled both inter and intra row weeds but hampering the plants growth and polluted environment if not apply the eco safe herbicides with proper dose and time. Some weeds considered as obnoxious are found to have allelochemicals that have the ability to control other weeds. Thus, all weeds are not harmful and also extracts of these weeds can be utilized for crop production or crop protection [6]. There are a number of plants found to have pesticidal properties available for insect and disease control, but relatively few natural herbicides have been investigated for the eradication of weeds or other invasive plants. Hence, intensive scientific research on weeds control with plant extracts combined with other weeds management practices will be needed for lesser cost effective and consistent integrated weeds management in the system of rice intensification. Keeping these aspects in view, the present investigation was conducted under field condition to study the growth and yield parameters and biological yield and to find out the economic advantages of various weed management treatments of summer transplanted paddy. The main objective of the work was prospects of biological weed management as an alternative of hand weeding or chemical weed management.

2. MATERIALS AND METHODS

The field experiment was conducted in humid sub-tropics of West Bengal at the Instructional Farm, Jaguli of Bidhan Chandra Krishi Viswavidyalaya (BCKV), Nadia, India during 2016-17. The experimental site is situated at 22°56’ E longitude and at an altitude of 9.75 m above the mean sea level (MSL). The experimental site is situated just south of the tropic of cancer with sub tropic humid climate. The soil of the experimental site was Gangetic alluvial with sandy clay loam texture (sand 47.21%, silt 20.23%, and clay 32.57%) with medium water holding capacity, the pH of the experimental soil was 6.83 with organic carbon of 0.61%, available nitrogen (N) of 234.50 kg ha^{-1}, available phosphorus (P) of 29.12 ka ha^{-1} and available potassium (K) of 150.32 kg ha^{-1}. The experiment was laid out in Randomised Block Design (RBD) with 3 replications and 8 treatments viz. T_1- Pre emergence *Tectona grandis* aqueous extract @ 100 mL/ L (PE Teak AE), T_2- Pre emergence *Bambusa vulgaris* aqueous extract 2 100 mL/ L (PE Bamboo AE), T_3- Pre- emergence pretilachlor 30.7 eC @ 500 g/ ha (PE Pretilacholar), T_4- Pre- emergence *Tectona grandis* aqueous extract @ 100 mL/L + *Bambusa vulgaris* AE @ 100 mL/ L (PE Teak AE + PE Bamboo AE), T_5- Pre-emergence *Tectona grandis* aqueous extract @ 100 mL/L + Pretilacholar @ 500 g/ha (PE Teak AE + Pretilachlor), T_6- Pre- emergence *Bambusa vulgaris* aqueous extract @ 100 mL/ L + Pretilachlor @ 500 g/ha (PE Bamboo + Pretilachlor), T_7 – Hand weeding at 25 & 45 DAT (HW), T_8- Weedy check (WC).

Rice variety IET 4786 after treating with salt water @ 160 g L^{-1} of water followed by *Trichoderma viride* @ 4 g kg^{-1} and Azotobacter @ 250 g kg^{-1} was broadcasted in nursery. The recommended fertilizer doses N: P_2O_5: K_2O @ 100:50:50 kg ha^{-1} were used in main field along with 2 t ha^{-1} neem cake (excepting in unprotected insect control plot). 20 days old seedlings were transplanted with 20 cm (Plant to Plant) and 25 cm (Row to Row) spacing during 3rd week of February and after 118 days crop was harvested. Irrigation was provided only to maintain the field in moist condition. Initially neem cake @ 2 t/ ha was applied after lay out along with the entire dose of P and 25% K at the time of sowing through single super phosphate and muriate of potash (MOP), respectively. No N was applied as basal instead 25% N in the form of Urea was applied at 10 days after transplanting (DAT). Rest of nitrogen (75%) and potash (75%) was applied in the form of urea and MOP in 3 equal splits (active tillering, panicle initiation and flowering). The water was drained out before top dressing of fertilizer. Irrigation was provided only to maintain the field in sufficient moist soil condition but not flooded condition. Water level of 3 cm was maintained at active tillering, panicle initiation and flowering stage. One week before harvesting the water was drained out.

For all the growth and development studies during the crop growth period, five plants were selected randomly and tagged in each plot. Initially the growth parameters (i.e – plant height (cm)), root length (cm), leaf area index (LAI), dry matter accumulation (gm^{-2}), Number of tillers (m^{-2}), Crop growth rate (g m^{-2} day^{-1}), were recorded at 25 days after sowing (DAS) and subsequent observations were taken at an interval of 25 days. Yield and yield attributing characters such as no of panicle (NPs) (m^{-2}), panicle length (PL) (cm), filled grains (FG) (%), the thousand grain weight (TGW) (g), grain yield (GY) (t ha^{-1}) and straw yield (SY) (t ha^{-1}), harvest Index (HI) (%) were determined using standard procedures. Finally yield was expressed as t ha^{-1}. The statistical analysis of randomised block design with 8 treatments was done by standard procedures suggested by Gomez and Gomez [7].

3. RESULTS AND DISCUSSION

3.1 Effect of Different Aqueous Botanical Herbicides on Various Growth Attributes

3.1.1 Plant height (cm)

The results pertaining to plant height (cm) of rice crop as recorded at 25, 50, 75 DAT and at harvest are presented in Table 1.

Plant height is a direct measurement to assess the growth of the plant. In general plant height increases at a faster rate up to flowering stage, thereafter, the observation in plant height is at a lower rate. The plant height of rice plant during 2016 data varied significantly at 25, 50, 75 DAT and at harvest in all observations against a different weed management treatments. The maximum plant height at 25 DAT was observed at T_5 (45.89) cm in closely followed by T_6 (45.73 cm). Lowest height was recorded at T_8 - 33.99 cm. All other treatments are significantly at per than weedy check data. All other treatments showed significantly among themselves but significantly higher thanT_8 (weedy check).

At 50 DAT highest plant height was observed at T_7 and lowest at T_8 with the value of 57.68 and 47.42 cm respectively. T_5 (53.38 cm) and T_8 (55.08 cm) also significantly at par than hand weeding that is T_7. At 75 DAT also all treatment were significantly varied. The highest plant height was observed at T_7 (71.52 cm) followed by T_5 (68.13 cm) and T_6 (69.37 cm). Lowest plant height was recorded T_8 (65.27 cm). In harvest data also same trend follows as 75 DAT. The data also followed of variation as that observed at 75 DAT.

Table 1. Effect of different weed management treatments on some growth indicators of summer transplanted rice during 2016- 2017

Treatment details	Plant height (cm) at harvest	Leaf Area Index (LAI) at 50 DAT	Root length (cm) at 50 DAT	Dry matter accumulation (g m^{-2}) at 75 DAT	Crop growth rate (g m^{-2} day^{-1}) at 50-75 DAT	Number of tillers m^{-2} at 60 DAT
T_1	92.78	4.19	24.98	656.15	12.79	386.00
T_2	95.27	4.20	25.70	649.77	12.82	377.00
T_3	91.54	4.26	26.94	665.43	12.90	404.33
T_4	95.51	4.28	27.55	657.63	12.41	398.00
T_5	96.2	4.31	30.20	673.41	12.61	412.00
T_6	96.84	4.30	28.06	680.57	12.68	418.67
T_7	98.75	4.41	30.41	696.69	13.02	438.33
T_8	83.23	3.77	23.61	598.33	11.19	347.33
S.Em (±)	1.967	0.068	0.571	4.59	0.20	7.072
CD at 5 %	6.026	0.209	1.749	14.057	0.58	21.659

- *AT – Date after transplanting*
- *LAT – Leaf area index*

Table 2. Effect of different weed management treatments on some yield attributes of summer transplanted rice during 2016- 2017

Treatment details	Panicle length (cm)	No. of panicle m^{-2}	Filled grains (%)	The thousand grain weight (g)
T_1	25.15	363.33	72.67	21.20
T_2	25.10	353.67	72.00	21.44
T_3	24.44	384.00	74.67	21.29
T_4	25.24	376.67	77.00	22.32
T_5	25.32	394.00	80.67	21.48
T_6	25.24	402.33	83.33	21.35
T_7	25.68	417.00	87.00	22.18
T_8	24.96	304.00	66.67	21.12
S.Em (±)	0.275	4.239	1.259	0.364
CD at 5 %	NS	12.982	3.856	NS

- *NS – Non Significant*

Table 3. Effect of different weed management treatments on biological yield and harvest index of summer transplanted rice during 2016-2017

Treatment details	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest index (%)
T_1	3.87	4.92	44.04
T_2	3.67	4.84	42.68
T_3	4.24	5.33	43.32
T_4	4.05	5.35	43.07
T_5	4.35	5.52	44.07
T_6	4.42	5.54	43.68
T_7	4.76	5.95	43.71
T_8	3.10	4.23	42.25
S.Em (±)	0.151	0.129	0.634
CD at 5 %	0.463	0.396	NS

- *NS – Non Significant*

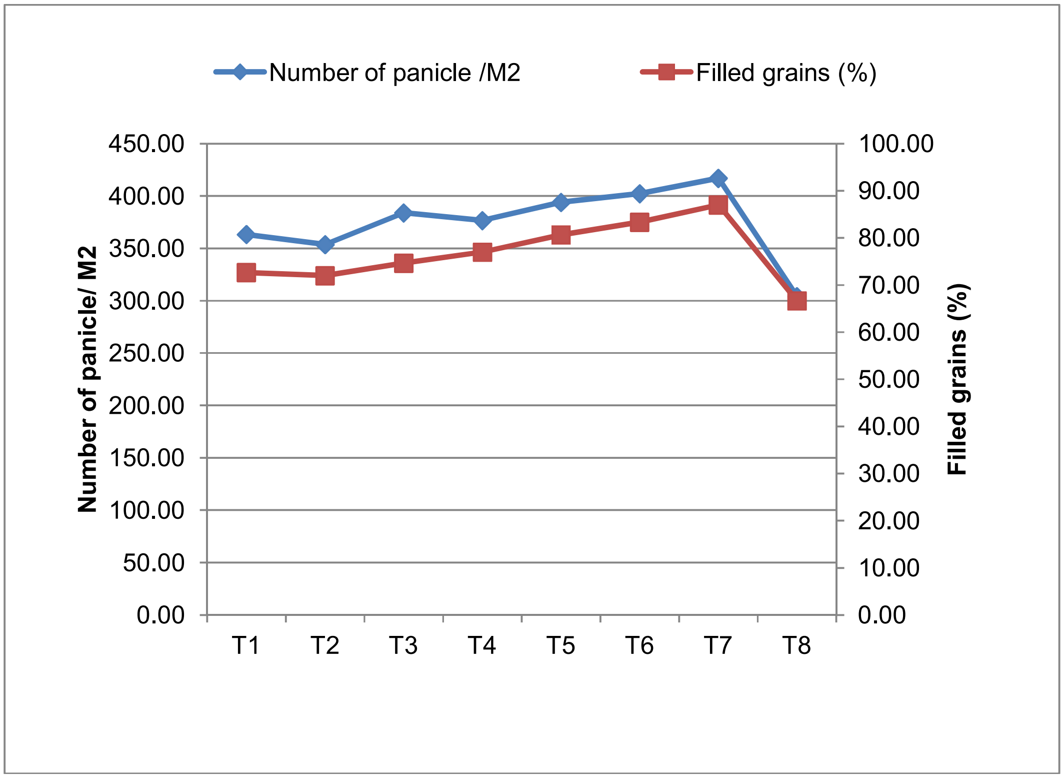

Fig. 1. Effect of different weed management treatments on number of panicle & percent filled grains

Table 4. Effect of different weed management treatments on economics of summer transplanted rice during 2016-2017

Treatment details	Economic advantages					
	General cost of cultivation	Cost of treatment (Rs. ha^{-1})	Total cost (Rs. ha^{-1}) (A)	Value of produce (Rs. ha^{-1}) (B)	Net profit (Rs.ha^{-1}) (B-A)	Benefit cost ratio value
T_1	32000	1200	33200	72810	39610	2.19
T_2	32000	1200	33200	69570	36370	2.09
T_3	32000	1500	33500	79590	46090	2.37
T_4	32000	2200	34200	76800	42600	2.24
T_5	32000	2300	34300	81810	47510	2.38
T_6	32000	2300	34300	82920	48620	2.41
T_7	32000	12000	44000	89250	45250	2.02
T_8	32000	0	32000	59460	27460	1.85

3.1.2 Root length (cm)

The root length of rice plant varied significantly at 25 and 50 DAT with different weed management treatments (Table 1). It clearly indicated that at 25 DAT root length was maximum against T_6 (17.63 cm) closely followed by T_5 (17.01 cm). Plant height of T_1, T_2, T_3, T_4, T_5 and T_6 were significantly higher than T_7 (HW) and T_8 (WC). The lowest root length was recorded by weedy check (T_7) at 25 and 50 DAT (13.66 cm and 23.61 cm respectively). But at 50 DAT highest root length was observed at T_7 (30.41 cm) followed by T_5 (30.20 cm) & T_6 (28.06 cm) are significantly at par with T_7.

3.1.3 Leaf Area Index (LAI)

The calculated LAI index as presented in Table 1 shows the data of two observation at 25 and 50

DAT. Measurement of leaf area is the basic growth analysis which is related to both biological and economical yields. The leaf area in general is progressively increasing upto flowering stage of the crop there after the increment was very low. The results revealed that the LAI of rice crop at 25 and 50 DAT changed significantly in different weed management treatments. The maximum value of LAI recorded was at 25 DAT in T_6 (2.56) and lowest at T_8 (2.17). But in 50 DAT maximum LAI observed at T_7 (4.41) and lowest at T_8 (3.77). The LAI data of T_3, T_4, T_5, and T_6 were significantly at par with T_7.

3.1.4 Dry matter accumulation (DMA) (g m^{-2})

Dry matter production gives a real picture of crop growth. The data was recorded at 25, 50 and 75 DAT. Biomass of the rice crop increased remarkably with the advancement of age of crop growth stages. The DMA of rice changed significantly at 25, 50 and 75 DAT with the different weed management treatments in the year 2016 (Table 1). The maximum dry matter at 25 DAT was 269.32 g m^{-2} at treatment T_6 followed by T_5 266.2 g m^{-2}. At 50 and 75 DAT maximum dry matter was observed at T_7 - (371.27 and 696.69 g m^{-2} respectively) followed by T_5 (358.15 and 673.41 g m^{-2} respectively), and T_6 (363.52 and 680.57 g m^{-2} respectively). Lowest dry matter was found at T_8 (318.70 and 598.33 g m^{-2} respectively).

3.1.5 Number of tillers (NTs) m^{-2}

In the experiment different weed management treatments had a significant role in the NT m^{-2} of paddy at 30 and 60 DAT during 2016 as shown in Table 1. Maximum NT m^{-2} at 30 DAT (236.33, 235.33 & 234.67 tiller m^{-2} respectively) was recorded by the rice crop receiving T_5 followed by T_6 and T_4 respectively. The least NTs m^{-2} (206.33) was recorded at 30 DAT. All treatments except T_1 were significantly at par than hand weeding treatment. At 60 DAT highest NTs m^{-2} (438.33) was recorded in T_7 then closely followed by T5 (412.00), and T_6 (418.67) NTs m^{-2}.

3.1.6 Crop Growth Rate (CGR) (g m^{-2} day^{-1})

Crop growth rate of rice was recorded during 25-50 DAT and 50-75 DAT and data are presented in Table 1. CGR data changed significantly with the different weed management treatments. The highest CGR value (3.93, 13.02 g m^{-2} day^{-1}) at 25 to 50 DAT and at 50 to 75 DAT respectively of paddy crop received under the treatment T_7 followed by T_6 (3.77 and 12.68 g m^{-2} day^{-1}, respectively) and T_5 (3.68, 12.61 g m^{-2} day^{-1}, respectively). Lowest CGR was observed at T_7 with the value of (3.10 & 11.19 g m^{-2} day^{-1}) at 25 to 50 DAT and 50 to 75 DAT respectively.

The mean data of NTs m^{-2}, LAI, DMA, CGR (Table 1) exhibited significant variation with differences in weed management treatments. T_7 showed better crop growth than T_1, T_2, T_3, T_4, T_5, T_6 and T_8. These results may be due to lesser weed pressure in T_7 in comparison to all other treatments. Similar findings were also reported [8,9,10]. But T_3 chemical treatment initially indicated slow rice growth rate due to the reason that during germination reduced amylase content that inhibits the plant growth.

The root length of rice changed significantly at 25 & 50 DAT with the different weed management practices (Table 1). The maximum root length recorded by the treatments T_6 (17.63 cm) followed by T_5, T_1, and T_4. At 50 DAT root length was observed maximum in T_7 (30.41 cm) followed by T_6 and T_5. The higher root length in treatment T_5, T_6 and T_7 is due to the reason that due to proper timely weed management the crop recorded better growth by getting more nutrients in comparison to other treatments.

3.2 Effect of Different Aqueous Botanical Herbicide on Various Yield Attributes

3.2.1 No of panicle (NPs) m^{-2}

The maximum NPs m^{-2} (Table 2) was recorded from the treatment T_7 (417) followed by T_6 (402.33) and T_5 (394.00) and these data were statistically higher than T_8 (WC). The lowest value was recorded from T_8 (WC) 304.00.

3.2.2 Panicle Length (PL) (cm)

The PL of rice did not show any significant variations among the treatments and the mean range was 24.44 to 25.68 cm (Table 2).

3.2.3 Filled Grains (FG) (%)

Maximum percent of FG was observed in T_7 (87%) followed by T_6 (83.33%) and T_5 (80.67%). The lowest FG was found in T_8 (66.67%) (Table 2 and Fig. 1).

3.2.4 The Thousand Grain Weight (TGW) (g)

Thousand grain weight of rice did not differ significantly with different weed management treatments (Table 2) and the range was 21.12 to 22.18.

3.3 Effect of Different Aqueous Botanical Herbicide on Yield and Harvest Index

3.3.1 Grain Yield (GY) (t ha^{-1}) and Straw Yield (SY) (t ha^{-1})

The data presented in Table 3 are showed the grain & straw yield and harvest index of summer transplanted paddy during 2016. The minimum grain (3.10 t ha^{-1}) & straw yield (4.23 t ha^{-1}) was obtained as expected, from the weedy check treatment (T_8) which was significantly lower than all other treatments used in this experiment. The treatments T_7 (HW) recorded the maximum biological yield (grain – 4.76 & straw 5.95 t ha^{-1}) and was statistically at par with the mixture of botanical and chemical treatments (T_5 -PE Teak AE @ 100 mL/L + Pretilachlor @ 500 g ha^{-1} - 4.35 and 5.52 t ha^{-1}respectively) and T_6 – (PE Bamboo AE @ 100 mL/L + Pretilachlor @ 500 g ha^{-1} - 4.42 and 5.54 t ha^{-1}, respectively). Among the two sole treatments which were recorded significantly lower biological yields than the above three treatments PE Teak AE @ 100 mL/L (T_1 grain 3.87 and straw 4.92 t ha^{-1}) showed better biological yield than that of the PE Bamboo AE @ 100 mL/L (T_2 grain 3.67 and straw 4.84 t ha^{-1}). The botanical mixture treatment T_4 also recorded significantly higher grain (4.04 t ha^{-1}) and straw (5.35 t ha^{-1}) than the weedy check.

3.3.2 Harvest Index (HI) (%)

The harvest index of rice crop is presented on Table 3. HI is the co-efficient of effectiveness of a crop. It is the economic yield or yield of the main product. The HI of crop rice did not show any significant effect. It was observed from the data that the maximum value (44.07%) was recorded by the treatment T_5 and the lowest value (42.25%) was obtained in WC (T_8).

3.4 Benefit - Cost Ratio (BCR)

Any weed control method could be recommended effective only when it becomes economically, socially and environmentally sound. Therefore, the costing of the treatment effects on weed control on the basis of economics is very much necessary. The economics of different treatments was worked out and relevant data have been presented in Table 4. The maximum cost of cultivation (Rs. 44000 ha^{-1}) was required in the treatment T_7 (HW) followed by T_4, T_5 and T_6 and the lowest cost of cultivation was required in weedy check (T_8). The T_6 (PE Bamboo + Pretilachlor) recorded highest BCR value of 2.41 followed by T_5 (PE Teak + Pretilachlor) with 2.38. But in case of treatment T_7 (HW), maximum cost of cultivation was incurred over all treatments due to higher expenditure on labour wages for that reason BCR ratio was comparatively lower (2.02) and the lowest B:C ratio was obtained against weedy check (T_8) 1.85.

4. CONCLUSION

In the present environment with the threat of climate change, food security is one of the most significant human development aspects. The rapid rise in population and also the price of food grains has endangered the food security of the whole world as well as India, poses a threat to the overall development of a nation and causing acute problems of hunger and malnutrition in countries. As a result only yield maximization is becoming the last word of modern agriculture as low productivity of major crops are the worrying factor. The "System of Intensification" (SI) which is the unique Best Management Practice (BMP) of the available resources need to be used by farmers with their improve thinking to increase the productivity in a sustainable way as it is of the major alternatives in this situation. Management of weeds is the key for pest management in SI methodology as weed is the major pest that causing more than one- third losses among the losses caused by the pests. In the system of intensification methodology using botanical herbicides and biological weed management is one of the major aspects considering the soil and environment aspects besides the input costs. In conclusion of the study, the crop growth, rice productivity, economics and farmers" easy availability the mixture treatments of AOBE (aqueous organic botanical extracts) *Bamboosa vulgaris* or *Tectona grandis* with SOCH (synthetic organic chemical herbicides) Pretilachlor may be the best option and is an alternative to traditional HW treatment for increasing rice productivity through ecosafe weed management in transplanted paddy.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Jagtap DN, Mahadkar UV, Chavan LS. Productivity and economics of rice

influenced by different crop establishment methods and fertilizer sources. Agricultural Journal. 2012;7(1):32-36.
2. FAO. Food and agriculture organization, FAOSTAT Database. Rome; 2015. Available:http://www.faostat.fao.org
3. Chopra NK, Chopra N. Effect of doses and stages of application of pyrazosulfuron-ethyl on weeds in transplanted rice. Indian Journal of Weed Science. 2003;35(1&2): 27-29.
4. Mukherjee D, Singh RP. Effect of micro-herbicides on weed dynamics, yield and economics of transplanted rice. Indian Journal of Agronomy. 2005;50(40):292-295.
5. Oudhia P, Pandey N, Tripathi RS. Allelopathic effects of weeds on germination and seedling vigor of hybrid rice. International Rice Research Notes. 1999;24(2): 1-1.
6. Hegab MM, Khodary SEA, Hammouda O, Ghareib HR. Autotoxicity of chard and its allelopathic potentialty on germination and some metabolic activities associated with growth of wheat seedlings. African Journal of Biotechnology. 2008;7(7):884-892.
7. Gomez KA, Gomez AA. Statistical procedures for agricultural research (2 ed.). John wiley and sons, New York. 1984;680.
8. Mishra D, Dandasena S, Bastia DK, Barik S, Tripathy S, Gulati JML. Performance of SRI method of organic rice cultivation under different agronomical management practices. In: National symposium on System of Rice Intensification (SRI) in India-policies, Instiutions and Strategies for scaling up, Coimbatore. 2008;30-32.
9. Chowdhury R, Kumar V, Sattar A, Brahmachari K. studies on the water use efficiency and nutrient uptake by rice under system of rice intensification. The Bioscan. 2014;9(1):85-88.
10. Baskar P, Siddeswaran K, Thavaprakaash N. Tiller dynamics, light interception percentage and yield of rice cultivars under System of Rice Intensification (SRI) as Influenced by Nursery Techniques and Spacing Madras Agric. J. 2013;100(1-3):131-134.

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