Current Journal of Applied Science and Technology

39(27): 88-95, 2020; Article no.CJAST.60889
ISSN: 2457-1024
(Past name: British Journal of Applied Science & Technology, Past ISSN: 2231-0843, NLM ID: 101664541)

Effect of Post Emergence Herbicides on Weed Management in Transplanted Kharif Rice (*Oryza sativa* L.) and Their Residuality on Soil Microorganisms

Ranjan Kumar Dey[1], Megha Sana[1*], Subhajit Pal[2], Ramyajit Mondal[1] and Sukanta Pal[1]

[1]Department of Agronomy, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, P.O. - Krishi Viswavidyalaya, Mohanpur-741252, Nadia, West Bengal, India.
[2]Department of Soil Science and Agricultural Chemistry, Faculty of Agriculture, Dr. Rajendra Prasad Central Agricultural University, Pusa (Samastipur), Bihar-848125, India.

Authors' contributions

This work was carried out in collaboration among all authors. Author RKD designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors RKD and SP managed the analyses of the study. Authors MS, SP and RM managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2020/v39i2730923
Editor(s):
(1) Dr. Frédéric Ngezahayo, Ecole Normale Supérieure, Burundi.
Reviewers:
(1) Meenakshi Sangwan, Chaudhary Charan Singh Haryana Agricultural University, India.
(2) Junaidi Sungei Putih, Indonesian Rubber Research Institute, Indonesia.
Complete Peer review History: http://www.sdiarticle4.com/review-history/60889

Original Research Article

Received 26 June 2020
Accepted 01 September 2020
Published 09 September 2020

ABSTRACT

The field experiments were conducted at Regional Research Sub-Station (new alluvial zone) of Bidhan Chandra Krishi Viswavidyalaya, Chakdaha, Nadia, West Bengal during *kharif* of 2015 & 2016 to study different post emergence herbicides against weed management in transplanted *kharif* rice. Ten (10) treatments were used following Randomize Block Design (RBD) with three replications. Among four different chemical herbicides Almix 20 WP @ 4 g ha^{-1} applied at 15 DAT as EPOE(early post emergence) effectively controlled all categories of weeds (mostly sedges and broad leaves) resulted minimum weed population, biomass production and higher weed control

**Corresponding author: E-mail: meghasana31@gmail.com;*

efficiency (WCE) at 30 and 45 DAT which ultimately produced higher grain yield (3.23 t ha-^{1}) compare to other treatments. In case of efficacy of phytotoxicity effects on experimental crop, toxicity effects on soil microflora and BC ratio, Almix 20 WP @ 4 g/ha reflects the satisfied result.

Keywords: Transplanted Kharif rice; herbicides; yield; microbial population.

1. INTRODUCTION

Rice occupies a pivotal place in Indian agriculture as it is the staple food for more than 70% of population and a source of livelihood for about 120-150 million rural households. It contributes about 43% of total food grain production and 46% of total cereal production in the country [1]. India needs to produce 120 mt of rice by 2030 to feed its one and a half billion plus population [2].There is no scope for horizontal expansion of cultivable area. Therefore, rice productivity and production have to be increased to meet the future demand.Weed is considered as a major pest and constraint to increase the production of rice [3]. In India, weed control takes 30-35 % share of total cost of crop production and the average yield loss is caused to the tune of 41.2 % [4]. In West Bengal under new alluvial zone the biological yield loss of rice due to weed was 37.02 % and 23.12 % in grain and straw, respectively [5]. This illustrates the importance of weed control in minimizing the yield losses and boosting up the crop productivity. Management of weeds at farm levels is still largely restricted to mechanical and cultural methods [6]. Proper management of weeds, in time, to reduce the crop-weed competition is not possible due to sharp increase in the wage and unavailability of labour due to industrialization and urbanization. In view of this, chemical weed control is becoming more popular throughout the world. Major competition with weeds in rice field occurs during initial 30-60 days in transplanted rice [7]. It calls for a detailed study on weed flora and their management in transplanted rice. Keeping an eye to develop an efficient eco-safe weed management practice for rice cultivation to replace those indigenous method of weed control through the use of effective, economic, socially and environmentally safe herbicides at proper dose, time and application.

2. MATERIALS AND METHODS

2.1 Experimental Site

A field experiment was conducted during 2015 and 2016 at Regional Research Sub-Station (RRS) of Bidhan Chandra Krishi Viswavidyalaya, Chakdaha, West Bengal India in transplanted rice (var- IET 4786). Soil was sandy clay loam type containing (46.50% sand, 25.0% silt and 28.5% clay) with a pH of 6.5. It contained 0.68% organic C, 215.2 kg available N ha^{-1}, 25.2 kg available P_2O_5 ha^{-1} and 142.4 kg available K_2O ha^{-1}. The climate of the study site was sub-tropical. Weekly maximum and minimum temperatures ranged between 31.3 to 36.7°C and 14.8 to 27.6 °C during 2015 and 2016 respectively. Maximum relative humidity ranged from 89% to 91.8% in 2017 and 89.2% to 93% in 2018 respectively. The annual rainfall during the experimental period was 1250.0 and 1400.5 mm in 2017 and 2018, respectively.

2.2 Herbicidal Treatments

The experiment was laid out in randomized block design with three replications. The area of each plot was 20 m^2 (5.0 m x 4.0 m) with an inter- row spacing of 20 cm. The treatments are consisted of 2, 4-D ethyl ester (80 EC) at five different dosages (425, 850, 1280, 1700 and 3400 g ha^{-1}), Butachlor (50 EC) @ 1000 g/ ha, Bispyribac sodium (10 SC) @ 25 g/ha and Almix (20 WP) @4 g/ha along with weedy check and weed free check. Dose of the herbicides was calculated as per treatments on the basis of gross plot area and were broadcasted uniformly in the experimental plots as per treatments. 2, 4-D EE was applied 25 DAT and others was applied 15 DAT with their different doses.

2.3 Crop Management Practices

Healthy paddy seeds (*cv.*IET 4786) soaked for 24 hours in clean water for better germination.The seeds were treated with *Trichoderma viride* @ 4 g kg^{-1} seed and shade drying for 6 hours prior to sowing. Well germinated seeds were sown on 27th and 29th June in 2015 and 2016. Twenty two days old seedlings were transplanted @ 3 seedling hill^{-1} at a spacing of 20 cm x 15cm in both the years. All other cultural and plant-protection measures were also adopted as recommended for the region (Banerjee and Pal, 2009). The individual plot size was 5m × 4m. One-fourth (¼th) N along with full P_2O_5 and ¾th K_2O of RDF were applied as basal (during final land preparation). Remaining ½ N was top-dressed at tillering stage, while ¼th each of N and K_2O was given at panicle initiation stage. Organic manures were applied 7 days before transplanting just to substitute a part of recommended dose of N. However, eco-safe protection measures were taken against yellow stem borer and rice bug. The crops were harvested manually with sickle at a height of 25-30 cm from ground level on 5th and 9th October in 2015 and 2016, respectively, then grain yield after threshing and cleaning was recorded from unit plot area and converted into t ha^{-1} at 15% moisture content.

2.4 Observations on Weeds

For weed count and weed biomass, required number of permanent quadrates (0.5 m x 0.5 m) were earmarked in each plot after rice sowing. For taking weed biomass, the destructed weed samples were first washed in clean tap water, then sun-dried and hot-air oven-dried at 70°C for 48 h, and weighed. Weed control efficiency (WCE) was worked out using following equations [8,9] respectively:

$$\mathrm{WCE} = \frac{\mathrm{WDM_c} - \mathrm{WDM_t}}{\mathrm{WDM_c}} \times 100$$

Where, WDM_c is the weed dry matter weight (g m^{-2}) in control plot; WDM_t is the weed dry matter weight (g m^{-2}) in treated plot.

2.5 Microbiological Observations

The enumeration of the microbial population was carried out on agar plates containing appropriate media following serial dilution technique and pour plate method [10].

2.6 Statistical Analysis

All the collected data was subjected to analysis of variance (ANOVA) according to the techniques define for simple randomized complete block design (RCBD) as described by Gomez and Gomez [11].

3. RESULTS AND DISCUSSION

3.1 Weed Population, Weed Dry Weight and Weed Control Efficiency

The experimental plots were infested with mixed weed flora where broadleaved weeds (BLW) were the most dominating followed by grassy weeds and sedges, irrespective of the dates of observations. Experimental results revealed that least weed population and weed biomass in terms of grasses, sedges and broadleaf weeds were registered under weed free check whereas maximum weed population was recorded under weedy check (Tables 1 and 2). Among the herbicidal treatments Almix 20 WP (4 kg ha^{-1}) resulted lowest weed population (17.1 and 19.0 m^{-2} respectively for 30 DAT and 45 DAT) and weed biomass(5.57 and 9.20 g m^{-2} respectively for 30 DAT and 45 DAT) throughout the growing period. The weed control efficiency also exhibited similar variations showing the superiority of Almix 20 WP by exerting 57.89 % and 57.97 % higher WCE at 30 and 45 DAT over control treatment, respectively. Unlike other three herbicides used in this experiment, Almix, a sulfonyl urea group herbicide, can able to control all categories of weeds as it is a mixture of Metsulfuron methyl (able to kill the dicot broadleaf weeds) and Chlorimuron ethyl (able to inhibit the monocot grassy weeds) by blocking the normal function of enzyme ALS/AHAS which is essential in amino acid (protein) synthesis. Without proteins, plants starve to death. These results were also in conformity with the findings of [12] and [13].

3.2 Growth and Yield Attributes

Hand weeding (T_9) recorded the maximum growth and yield attributing characters. Among the herbicidal treatments, the pooled data of two years showed that Almix 20 WP @ 4 g ha^{-1} applied as EPOE was recorded the maximum growth and yield attributing characters exhibiting 19.0 % more plant height at 65 DAT; 12.1 % higher LAI at 60 DAT; 8.3 % higher number of panicle m^{-2}, 15.8 % panicle weight, 24.0 % more panicle length, 30.2 % higher percent filled grains panicle^{-1} and 23.4% higher harvest index over unweeded control (Table 3). This better result of Almix may because of its capability to improve the crop growth by suppressing all categories of weeds as a result of which the crop paddy received minimum competition from weed and utilize the resources maximum. Similar kind of results reported by [14] and [15].

Table 1. Effect of treatments on population of dominant grassy, sedges and broadleafweedsinrice (Pooled value of 2 years)

Tr. no	Treatment	Dose a.i. g ha^{-1}	*Echinochloa Spp*		*Leptochloa chinensis*		*Cyperus iria*		*Cyperus difformis*		*Sphenoclea zeylannic*		*Ludwigia octovalvis*	
			30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT
T_1	2, 4-D Ethyl Ester 80 EC	425	4.69	5.46	5.34	7.65	5.74	6.62	5.41	6.72	1.55	2.02	1.76	2.01
T_2	2, 4-D Ethyl Ester 80 EC	850	4.63	5.39	5.29	7.64	5.65	6.59	5.36	6.61	1.41	1.85	1.57	1.91
T_3	2, 4-D Ethyl Ester 80 EC	1280	4.63	5.32	5.21	7.50	5.54	6.53	5.28	6.58	1.21	1.64	1.45	1.67
T_4	2, 4-D Ethyl Ester 80 EC	1700	4.51	5.35	5.22	7.46	5.62	6.50	5.32	6.52	1.10	1.29	1.21	1.58
T_5	2, 4-D Ethyl Ester 80 EC	3400	4.38	5.30	5.17	7.33	5.59	6.39	5.31	6.43	0.94	1.11	1.06	1.20
T_6	Butachlor 50 EC	1000	2.36	2.67	2.29	2.92	2.36	2.55	2.37	2.62	2.45	2.62	2.63	3.22
T_7	Bispyribac sodium 10 SC	25	2.12	2.16	2.10	2.42	2.13	2.45	2.23	2.31	2.40	2.50	2.59	3.13
T_8	Almix 20 WP	4	1.73	1.77	1.94	2.05	1.61	2.08	2.02	1.98	2.11	2.16	2.04	2.65
T_9	Hand weeding twice (HW)	20 & 40 DAT	1.16	1.58	1.47	1.81	1.15	1.48	1.34	1.72	1.44	1.59	1.81	2.22
T_{10}	Weedy Check (WC)	-	4.99	5.78	5.55	7.92	5.98	6.94	5.67	7.02	7.03	7.60	6.52	7.54
C.D. (P=0.05)			0.49	0.52	0.48	0.45	0.41	0.53	0.39	0.45	0.47	0.45	0.30	0.63

Table 2. Effect of treatments on total weed population, weed dry weight and weed control efficiency (Pooled value of 2 years)

Tr. no	Treatment	Dose a.i. g ha^{-1}	Total weed Population (m^{-2})		Total weed Dry weight (g m^{-2})		WCE (%)	
			30 DAT	45 DAT	30 DAT	45 DAT	30 DAT	45 DAT
T_1	2, 4-D Ethyl Ester 80 EC	425	36.7	45.7	10.42	16.73	21.27	23.79
T_2	2, 4-D Ethyl Ester 80 EC	850	35.9	44.6	10.18	16.07	22.95	26.78
T_3	2, 4-D Ethyl Ester 80 EC	1280	35.0	43.1	10.10	15.99	23.59	27.02
T_4	2, 4-D Ethyl Ester 80 EC	1700	34.5	42.1	10.02	15.21	24.18	30.95
T_5	2, 4-D Ethyl Ester 80 EC	3400	32.7	40.7	9.95	15.12	24.61	31.08
T_6	Butachlor 50 EC	1000	21.7	24.9	6.29	11.34	52.49	48.45
T_7	Bispyribac sodium 10 SC	25	20.4	22.4	5.92	9.67	55.22	55.79
T_8	Almix 20 WP	4	17.1	19.0	5.57	9.20	57.89	57.97
T_9	Hand weeding twice (HW)	20 & 40 DAT	12.6	15.6	4.47	7.81	66.20	64.42
T_{10}	Weedy Check (WC)	-	56.5	65.8	13.24	22.02	--	--
C.D. (P=0.05)			2.51	2.25	0.50	1.68	--	--

Table 3. Effect of treatments on growth, yield attributes and yield of rice (Pooled value of 2 years)

Tr. No	Treatment	Dose a.i. g ha^{-1}	Growth Parameters		Yield Attributes and Yield							
			Plant Height (65 DAT)	LAI (65 DAT)	No of panicle m^{-2}	Panicle weight (g)	Panicle length (cm)	Filled grains $panicle^{-1}$ (%)	1000-grain weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	Harvest Index
T_1	2, 4-D Ethyl Ester 80 EC	425	75.63	3.29	311	2.23	22.54	80.0	17.44	2.91	4.29	40.39
T_2	2, 4-D Ethyl Ester 80 EC	850	75.96	3.32	313	2.24	22.83	82.3	17.48	3.00	4.33	40.96
T_3	2, 4-D Ethyl Ester 80 EC	1280	75.63	3.34	316	2.26	22.92	83.8	17.52	3.07	4.36	41.31
T_4	2, 4-D Ethyl Ester 80 EC	1700	75.63	3.33	317	2.27	23.00	84.6	17.55	3.13	4.38	41.67
T_5	2, 4-D Ethyl Ester 80 EC	3400	76.91	3.38	320	2.29	23.32	86.2	17.64	3.16	4.42	41.68
T_6	Butachlor 50 EC	1000	79.74	3.41	322	2.31	23.58	89.2	17.73	3.17	4.44	41.71
T_7	Bispyribac sodium 10 SC	25	78.65	3.42	323	2.31	23.57	88.5	17.90	3.20	4.46	41.73
T_8	Almix 20 WP	4	81.78	3.44	325	2.34	23.69	93.1	18.19	3.23	4.49	41.81
T_9	Hand weeding twice (HW)	20 & 40 DAT	82.82	3.50	326	2.36	23.77	96.2	18.37	3.25	4.53	41.76
T_{10}	Weedy Check (WC)	-	68.70	3.07	300	2.02	19.10	71.5	17.18	2.03	3.95	33.88
C.D. (P=0.05)			3.91	0.14	6.70	0.10	0.98	5.54	NS	0.21	0.11	2.71

Table 4. Effect of treatments on total microflora in soil of wet season rice after harvest (Mean value of 2 years)

Tr. no	Treatment	Dose a.i. g ha^{-1}	Microbial Population		
			Total bacteria (CFU x 10^6)	Total Actinomycetes (CFU x 10^5)	Total Fungi (CFU x 10^4)
T_1	2, 4-D Ethyl Ester 80 EC	425	152.5	131.1	14.1
T_2	2, 4-D Ethyl Ester 80 EC	850	149.7	124.9	13.9
T_3	2, 4-D Ethyl Ester 80 EC	1280	149.0	126.5	13.6
T_4	2, 4-D Ethyl Ester 80 EC	1700	149.8	126.4	13.6
T_5	2, 4-D Ethyl Ester 80 EC	3400	149.8	124.3	13.9
T_6	Butachlor 50 EC	1000	149.0	126.1	13.7
T_7	Bispyribac sodium 10 SC	25	151.8	124.2	13.7
T_8	Almix 20 WP	4	149.4	127.4	13.7
T_9	Hand weeding twice (HW)	20 & 40 DAT	153.6	132.7	14.6
T_{10}	Weedy Check (WC)	-	136.2	120.1	11.5
	Initial	-	136.5	139.2	15.7

3.3 Grain and Straw Yield

In Lieu Of weed free check, Significant (*$p \leq 0.05$*) higher yield were exhibited from all the herbicide application treatments as compared to non-treated control. Differential herbicide management had resulted significant grain yield variation of rice *cv*. Satabdi ranging from 2.91 to 3.23 t ha^{-1}. Among the herbicidal treatments, the pooled data of two years showed that Almix 20 WP @ 4 g ha^{-1} applied at 15 DAT as EPOE recorded maximum grain and straw yield which were 59.1 % and 32.7 % higher than unweeded control, respectively (Table 3) but the treatments are statistically similar with each other. The highest harvest index (41.81%) was obtained from T8 treated plot, which was statistically at par with all treatments except control (33.88%). In case of Almix the higher yield over the other herbicide treatments were recorded and this may be due to the higher growth and yield parameters which is the resultant effects of the inhibition of all weed flora by blocking the normal function of enzyme ALS/AHA. Similar kind of view was expressed by [15] and [16]. Advantages of herbicide application and judicious weed management strategies in improving yield attributes and yield of several crops are supported also by various other research reports [17].

3.4 Soil Microbial Population

The impact of application of different herbicide on total bacteria (*Pseudomonus fluorescence),* total fungi *(Trichoderma viridae, Trichoderma harzianum)* and Actinomycetes were recorded during harvesting of rice (Table 4). Different weed management treatments significantly (*$p \leq 0.05$*) influence the soil microbial populations. Bacterial population sharply hampered by the application of 2, 4-D ethyl ester (3.4 kg ha^{-1}) as compared to herbicide free plot *i.e*. weedy check and weed free check. However, lowest fungal and actinomycetes population were depicted from the treatment treated with bispyribac-sodium 10% SC. In case of Almix 20 WP bacterial fungal and actinomycetes population was 149.4 CFU x 10^5, 13.7 x 10^4 and 127.4 x 10^5 respectively, which gave the satisfied result in case of soil microbial population. The population of soil micro flora was increased with lowering doses of herbicides and ultimately weed free check and weedy check resulted significantly greater microbial population respectively. It is also obtained in the findings of [18], who have reported that there was no longer harmful effects of herbicides generally on soil microbial population except in case of higher concentrations beyond recommended doses. This is might be due to the fact that microorganisms are able to degrade herbicides and utilize them as a source of biogenic elements for their own physiological processes [19]. At harvest the soil microflora population was higher than that observed in prior two observations in all four herbicides used in experiments. Kundu, et al. [20] also observed similar views.

4. CONCLUSION

From this experiment, it can be concluded that although hand weeding twice at 20 and 40 DAT effectively control all categories of weeds and recorded maximum grain yield (3.25 t ha^{-1}), it was statistically at par with the Almix 20% WP (T_8) treatment which was an effective treatment in respect of all types of weed population, biomass production and weed control efficiency throughout the observation period and resulted in about 59.1 % yield increment of rice over control without showing any phytotoxicity on plants. Based on overall performance, we could be suggested thatthe application of Almix 20% WP @ 4g a.i. ha^{-1}exploit not only better weed management but also improves the yield of rice. Further research is needed to evaluate the carry over effect of herbicides towards next cropping window, and develop timing strategies with minimum effective dosages which could be most economic and ecologically desirable weed management approach for rice based cropping system in eastern India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Directorate of Rice Development, Problems & Prospects of Rice Export from India; 2011.
2. Adhya TK. Vision 2030: Central Rice Research Institute Technical Bulletin, Cuttack, Odisha. 2011;22.
3. Labrada R. Weed control in rice. (In): Weed management in rice. FAO Plant production and protection paper, 139 (Eds. B.A. Auld and K.U. Kim). Food and Agricultural organization of the United Nations, Oxford and IBH Pub. Co. Pvt. Ltd. 1996;3-5.
4. Bhan VM. Vision-2020. National Research Centre for Weed Science. Perspective plan. 1997;53.
5. Mondal D, Ghosh A, Shamurailatpam D, Mandi G, Karmakar C, Ghosh RK. Estimation of losses due to pests in summer rice (*Oryza sativa* L.) in gangetic alluvial zone of West Bengal. National Seminar on ‘Sustainable Agriculture for Food Security and Better Environment’ organized by Department of Agronomy, BCKV is scheduled during at FACC, BCKV. Extended Summary. 2015;188-189.
6. Yaduraju NT, Mishra JC. Herbicides Boom or Bene. Keynote address in the opening of WBCISWS, BCKV; 2002.
7. Kumar V, Bana OPS, Rajpur PR. Weed management in rice. Indian Farmers Digest. 1998;31-34.
8. Banerjee H, Garai S, Sarkar S, Ghosh D, Samanta S, Mahato M. Efficacy of herbicides against canary grass and wild oat in wheat and their residual effects on succeeding greengram in coastal Bengal. Indian J. Weed Sci. 2019;51:246. Available:https://doi.org/10.5958/0974-8164.2019.00052.2
9. Kundu R, Mondal M, Garai S, Poddar R, Banerjee S. Efficacy of herbicides against broad-spectrum weed floras and their effect on non-target soil micro-organisms and productivity in sugarcane (*Saccharum* sp.). Curr. J. Appl. Sci. Technol. 2020;23–32. Available:https://doi.org/10.9734/cjast/2020/v39i230493.
10. Pramer D, Schmidt E L.Experimental soil microbiology. Burgess Publ; 1965.
11. Gomez KA, Gomez AA. Statistical Procedures for Agricultural Research.John Wiley and Sons, New York; 1984.
12. Ghosh P, Mukherjee N, Bowmick M.K. and Ghosh R. K. Eco-friendly chemical weed management in transplanted kharif rice. (In): Extended Summaries, Natural Biennial Conf. ISWS, PAU. 2005;15-16.
13. Pal S, Ghosh RK, Banerjee H, Kundu R, Alipatra A. Effect of pyrazosulfuron ethyl on yield of transplanted rice. Indian J. Weed Science. 2012;44(4):210-213.
14. Mukhopadhyay SK. Weed management in *boro* rice. Boro rice technology: A manual (Eds. Dasgupta D, Gangopadhyay PK, Das AK), Pallysree Press, Sriniketan Rd., Bolpur, West Bengal. 1995;70-77.
15. Pal D, Dolai AK, Ghosh RK, Mallick S, Mandal D, BaruiK. Bio-efficacy and phytotoxicity of ethoxysulfuron on the weed control and yield performance of in transplanted kharif rice in Gangetic Alluvial soil of West Bengal .Journal of Crop and Weed. 2007;4(1):38-40.
16. Ghosh RK, Mondal SS, Maity S. Modern Weed Science Manual published by Department of Agronomy, Bidhan Chandra Krishi Viswavidyalaya. 2007;43-44.

17. Farooq M, Siddique KH, Rehman H, Aziz T, Lee DJ, Wahid A. Rice direct seeding: experiences, challenges and opportunities. Soil and Tillage Research, 2011;111(2):87-98.
18. Das TK, Sakhuja PK, Zelleke H. Herbicide efficacy and non-target toxicity in highland rainfed maize of Eastern Ethiopia. Int J Pest Manag. 2010;56:315–325.
19. Bera S, Ghosh RK. Soil microflora and weed management as influenced by atrazine 50 % wp in sugarcane. Universal Journal of Agricultural Research. 2013; 1(2):41-47.
20. Kundu R, Mondal R, Garai S, Mondal M, Poddar R, Banerjee S. Weed management efficiency of post emergence herbicides in direct seeded rice and their residuality on soil microorganisms. Journal of Experimental Biology and Agricultural Sciences. 2020; 8(3):276-286.

Peer-review history:
The peer review history for this paper can be accessed here:
http://www.sdiarticle4.com/review-history/60889