Indian Journal of Agricultural Sciences **85** (2): 283–6, February 2015/Article

Energy and nutrient utilization in rice (*Oryza sativa*)-weed ecosystem under post emergence herbicide application

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Received: 27 September 2013; Revised accepted: 28 October 2014

ABSTRACT

A field experiment was carried out during 2010 and 2011 at the Research Farm of Krishi Nagar, J N Krishi Vishwa Vidyalaya, Jabalpur (Madhya Pradesh). The treatments consisted of weed control practices, viz. bispyribac sodium, penoxsulam, pyrazosulfuron-ethyl, cyhalofop-butyl + almix, fenoxaprop-p-ethyl + almix and control as main plot treatment and three day time application (morning, afternoon and evening) as sub plot treatment and laidout in split plot design in three replications. In rice *(Oryza sativa* L.)-weed ecosystem the solar energy utilization by weeds was maximum under control plot (836.46 and 786.52 lakh k cal/ha) where transplanting of crop was done without controlling of weeds, whereas pyrazosulfuron-ethyl treated plot registered lowest energy utilization (285.21 and 286.78 lakh k cal/ha) by weeds during both the years. The energy utilization by crop grain and straw was maximum with post emergence application of pyrazosulfuron-ethyl (527.83 and 533.65; 274.20 and 280.00 lakh k cal/ha). The studies on NPK removal by weeds and uptake by crop showed that the weed control treatments caused significant variations on these parameters. Application of pyrazosulfuron-ethyl also reduced the N (4.90 and 4.33 kg/ha), P (0.34 and 0.29 kg/ha) and K (3.76 and 3.30 kg/ha) removal by weeds as compared to other herbicides and weedy check during both the years. The N (166.54 and 169.19 kg/ha), P (49.10 and 49.64 kg/ha) and K (170.95 and 173.13 kg/ha) uptake by crop was recorded higher with the application of pyrazosulfuron-ethyl. However, different day time application of post emergence herbicides was found statistically non-significant for energy and nutrient utilization by weeds and crop.

Key words: Energy and nutrient utilization, Post emergence herbicides, Rice

In India, rice (*Oryza sativa* L.) is the most important and extensively grown food crop, occupying about 43.97 million ha of cultivated land with production of 104.32 million tonnes and productivity 2 372 kg/ha, respectively (Agriculture Statistics at a Glance 2012). Rice occupies a pivotal place in Indian agriculture and is the staple food for more than 70 per cent of population and a source of livelihood for about 120-150 million rural households. In transplanted rice initially seedling grows slowly which encourage the rapid growth of weeds. Weeds are major impediment to crop production although their ability to compete for resources and their impact on production quality. Weed competition with crops for plants nutrients is a major factor in reduction of crop yield. Weeds often competitive because of their greater ability to remove nutrients form soil profile. Effective control of weeds is vitally important not only to check the losses caused by them but also to increase the fertilizer use efficiency. An estimate shows that weeds can deprive the crops by 47% N, 42% P, 50% K, 39% Ca and 24% Mg of their nutrient uptake as well as reduce the yield potential by harbouring number of crop pests (Balasubramaniyan and Palaniappan 2001). Herbicides application greatly affect the nutrient uptake by weeds and wheat (Thakur and Singh 1989 and Bainade and Patel 1991).

Manual and mechanical measures are not only costly and labour intensive, but also take more time. Presently, there are various broad-spectrum post emergence herbicides for effective control of weeds in rice crop. The herbicide molecules were also affected by the day time application of herbicide. Herbicide and day time may interact with each other for controlling the weeds and increase the grain yield of rice. Post emergence herbicides are more effective if applied at one specific time of day or at another. The studies of Weaver and Nyland (1965) first pointed out the importance of investigating variation in susceptibility of weeds and crop plants to herbicides applied at different times of day. Different herbicidal treatments also affect the energy and nutrient utilization by weeds and crop (Jain *et al.* 1998 and Bhowmick 2001). Hence, present study has been planned to find out the effect of post emergence herbicides in relation to energy and nutrient utilization under paddy cultivation.

MATERIALS AND METHODS

The experiment was conducted at the research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, Madhya Pradesh during *kharif* 2010 and 2011. Jabalpur lies between 22° 49’ to 24° 8’ North latitude and 78° 21’ to

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Table 1 Grain and straw yield of rice (kg/ha)

Treatment	Grain yield		Straw yield	
	2010	2011	2010	2011
Herbicides				
Bispyribac sodium	5364.11	5478.56	10338.29	10635.11
Penoxsulam	5668.22	5784.33	10945.50	11297.00
Pyrazosulfuron-ethyl	6347.33	6481.56	12275.04	12410.56
Cyhalofop-butyl + almix	5375.22	5728.00	10399.83	11034,56
Fenoxaprop-p-ethyl + almix	6170.44	6256.66	11928.94	12004.78
Control	4260.00	4631.56	6484.08	7104.33
SEm ±	21.73	23.45	89.67	78.19
CD (P=0.05)	65.19	70.35	269.01	234.57
Time of application				
Morning	5528.06	5747.78	10378.26	10756.06
Afternoon	5494.61	5669.28	10389.51	10604.33
Evening	5570.00	5763.22	10418.07	10882.78
SEm ±	37.88	36.09	39.89	91.36
CD (P=0.05)	NS	NS	NS	NS
SEm ± (Interaction)	33.46	38.96	33.09	34.44
CD (P=0.05)	NS	NS	NS	NS

80° 58' East longitude at an average altitude of 411.78 m above the mean sea level. Soil of the experiment was clayey with neutral pH (7.12), medium in organic carbon (0.68%), N (272 kg/ha), and P (15.50 kg P_2O_5/ha) and high in K (295 kg K_2O/ha). The experiment was laid out in split plot design with three replications. The main factor consisting different chemical weed control treatments, viz. bispyribac sodium, penoxsulam, pyrazosulfuron-ethyl, cyhalofop-butyl+almix, fenoxaprop-p-ethyl+almix and control. In sub plot three times of applications of herbicidal treatments were taken, viz. morning (8 am to 9 am), afternoon (12 noon to 1 pm) and evening (4 pm to 5 pm).

Rice variety, WRL 32100 was transplanted in 20 cm × 20 cm planting geometry with a basal dose of 120 kg of N, 60 kg of P_2O_5 and 40 kg of K_2O. One fourth (25%) of recommended dose of nitrogenous fertilizer along with full quantity of P and K fertilizers were applied at the time of transplanting of seedlings (basal application) as per treatments. Remaining N was top dressed in two equal split doses at 20 and 45 days after transplanting (DAT). The spraying of herbicides was done by mixing the required quantity of herbicide in measured quantity of water at the rate of 500 liters/ha using Knapsack sprayer with flat fan nozzle. The nutrient analysis in weeds, crop and soil was done as per standard methods. The energy utilized by weeds and crop was determined as per Leisth (1965) who reported energy content is 4.30 k cal/g weed dry weight and crop straw. However, Gopalan *et al* (1971) reported the energy content is 4.52 k cal/g of crop grain. These factors were used for the conversion the dry weight of weeds and crop grain yield into energy content.

Table 2 Effect of different post emergence herbicides and day time application on energy utilization (lakh k cal/ha)

Treatments	Morning		Afternoon		Evening		Mean	
	2010	2011	2010	2011	2010	2011	2010	2011
Weeds								
Bispyribac sodium	498.44	459.03	622.40	576.10	488.35	448.27	536.40	494.47
Penoxsulam	408.97	354.85	486.39	422.85	399.95	339.09	431.77	372.26
Pyrazosulfuron-ethyl	264.36	226.66	345.40	300.37	245.87	213.32	285.21	246.78
Cyhalofop-butyl + almix	453.62	390.99	529.71	465.88	440.70	383.30	474.68	413.39
Fenoxaprop-p-ethyl + almix	325.37	260.75	400.88	348.72	311.23	254.13	345.83	287.87
Control	836.38	775.35	836.56	792.08	836.45	792.13	836.46	786.52
Mean	464.52	411.27	536.89	484.33	453.76	405.04		
Crop straw								
Bispyribac sodium	441.87	445.62	443.03	463.58	448.74	462.72	444.55	457.31
Penoxsulam	469.81	490.52	465.76	473.32	476.40	493.48	470.66	485.77
Pyrazosulfuron-ethyl	526.44	540.42	526.32	524.60	530.72	535.94	527.83	533.65
Cyhalofop-butyl + almix	445.27	479.51	448.37	459.35	447.93	484.60	447.19	474.49
Fenoxaprop-p-ethyl + almix	512.26	519.17	519.04	504.46	507.54	524.99	512.94	516.21
Control	281.94	299.82	277.97	310.60	276.54	306.03	278.82	305.49
Mean	446.27	462.51	446.75	455.99	447.98	467.96		
Crop grain								
Bispyribac sodium	230.41	239.63	230.76	233.15	234.01	237.24	231.73	236.67
Penoxsulam	244.99	248.80	241.20	248.49	248.41	252.36	244.87	249.88
Pyrazosulfuron-ethyl	274.51	281.81	271.35	276.65	276.75	281.55	274.20	280.00
Cyhalofop-butyl + almix	232.21	249.98	230.86	242.52	233.55	249.84	232.21	247.45
Fenoxaprop-p-ethyl + almix	267.13	270.73	264.61	269.08	267.94	271.04	266.56	270.28
Control	183.61	198.86	185.41	199.58	183.07	201.80	184.03	200.08
Mean	238.81	248.30	237.37	244.91	240.62	248.97		

Table 3 NPK content (%) of different weed species in rice

Weed species	Nitrogen (N)	Phosphorus (P)	Potassium (K)
Echinochloa colona	0.80	0.24	3.60
Paspalum distichum	0.72	0.23	3.20
Ludwigia perennis	0.58	0.22	1.45
Cyperus iria	0.60	0.26	1.70
Fimbristylis miliacea	0.62	0.24	1.68
Alternanthera philoxeroides	0.95	0.35	2.5
Caesulia axillaris	0.70	0.24	2.42
Eclipta alba	0.72	0.25	2.50

RESULTS AND DISCUSSION

Energy utilization

Solar energy utilization by weeds was maximum under control plot (836.46 and 786.52 lakh k cal/ha) where no management practices done (Table 2). Application of pyrazosulfuron-ethyl controlled broad spectrum weed flora and registered 285.21 and 246.78 lakh k cal/ha lower energy utilization during both the years. Jain *et al.* 1998 also reported that the solar energy utilization by weeds was higher (178.37 lakh k cal/ha) in weedy check. The evening and morning time application of post emergence herbicides recorded lower energy utilization by weeds than afternoon time during both the years.

Energy utilization by crop grain was the maximum under post emergence application pyrazosulfuron-ethyl (274.20 and 280.00 lakh k cal/ha). However, the control plot utilized lowest solar energy (184.03 and 200.08 lakh k cal/ha) due to lower grain yield. Similarly rice straw also recorded higher energy utilization with higher under pyrazosulfuron-ethyl treated plot (527.83 and 533.65 lakh k cal/ha). Lowest energy utilization was in rice straw in control plot (278.82 and 305.49 lakh k cal/ha). Similarly, higher (153.28 lakh k cal/ha) solar energy, utilization in rice grain obtained under chemical weed control however, lower (101.38 lakh k cal/ha) in rice associated with weeds under weedy check (Jain *et al*. 1998). Rice grain and straw utilized lowest solar energy with morning and evening time of post emergence application.

Nutrient removal by weeds

The NPK content in different weed species revealed that the maximum nitrogen and phosphorus content (Table 3) was found in *Alternanthera philoxeroides* (0.95 and 0.35 %) followed by *Echinochloa colona* (0.80 and 0.24%), however minimum in *Ludwigia perennis* (0.56 and 0.22 %). The potassium content was the maximum in *Echinochloa colona* (3.60%) and minimum in *Ludwigia perennis* (1.45%).

Based on NPK content of different weed species *Alternanthera philoxeroides* utilized the maximum NPK (89.49, 32.97, 235.50 kg/ha) under control plot followed by *Cyperus iria*, (56.82, 24.62,160.99 kg/ha), *Fimbristylis miliacea* (51.87, 20.08, 140.56 kg/ha) and *Echinochloa colona* (48.88, 14.65, 219.73 kg/ha). Among the different weed control methods post emergence application of pyrazosulfuron-ethyl was found the most effective and *Echinochloa colona* utilized minimum NPK (10.07, 3.02, 45.31 kg/ha) followed by *Fimbristylis miliacea* (22.53, 8.72, 61.04 kg/ha)

The lowest mining of N (4.90 and 4.33 kg/ha), P (0.34 and 0.29 kg/ha) and K (3.76 and 3.30 kg/ha) by total weeds was recorded with pyrazosulfuron-ethyl application due to effective control on weeds during both the years (Table 5). The highest nutrient removal of N (17.84 and 17.29 kg/ha), P (1.52 and 1.47 kg/ha) and K (16.25 and 15.74 kg/ha) was recorded under weedy check because of highest weed density and dry weight during both the years. Singh *et al.* (2001) also observed that the untreated rice recorded the highest number of associated weeds, and hence the highest nutrient removal by the weeds, and lowest nutrient uptake by the crop.

Nutrient uptake by crops

The nutrient uptake by crop in the herbicide treated plots assimilated higher N, P, and K over weedy check plots during both the years. Similarly higher uptake of N (166.54

Table 4 NPK removal by four dominated weeds (kg/ha)

Treatment	*Echinochloa colona*			*Cyperus iria*			*Fimbristylis miliacea*			*Alternanthera philoxeroides*		
	N	P	K	N	P	K	N	P	K	N	P	K
Herbicides												
Bispyribac sodium	24.77	7.43	111.47	45.58	19.75	129.14	34.66	13.42	93.93	56.55	20.84	148.83
Penoxsulam	19.68	5.90	88.56	33.74	14.62	95.61	33.17	12.84	89.88	47.17	17.38	124.12
Pyrazosulfuron-ethyl	10.07	3.02	45.31	28.95	12.55	82.03	22.53	8.72	61.04	29.49	10.87	77.61
Cyhalofop-butyl + almix	23.97	7.19	107.87	38.34	16.61	108.63	33.46	12.95	90.67	52.20	19.23	137.36
Fenoxaprop-p-ethyl + almix	16.44	4.93	73.98	30.10	13.04	85.27	24.45	9.47	66.26	36.17	13.32	95.18
Control	48.83	14.65	219.73	56.82	24.62	160.99	51.87	20.08	140.56	89.49	32.97	235.50
Time of application												
Morning	22.80	6.84	102.61	37.30	16.17	105.70	32.62	12.63	88.40	49.62	18.28	130.57
Afternoon	26.87	8.06	120.91	42.83	18.56	121.35	35.36	13.69	95.83	57.77	21.29	152.04
Evening	22.21	6.66	99.95	36.63	15.87	103.79	32.08	12.42	86.94	48.14	17.74	126.69

Table 5 Effect of different post emergence herbicides and day time application on nutrient removal by weeds and nutrient uptake by crop in transplanted rice (kg/ha)

Treatments	Nutrient removal by weeds						Nutrient uptake by crop					
	Nitrogen		Phosphorus		Potassium		Nitrogen		Phosphorus		Potassium	
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
Herbicides												
Bispyribac sodium	10.33	9.45	0.87	0.79	9.30	8.51	140.49	144.02	41.35	42.54	144.06	148.02
Penoxsulam	8.01	6.73	0.59	0.49	6.92	5.82	148.60	152.54	43.78	45.19	152.47	157.07
Pyrazosulfuron-ethyl	4.90	4.33	0.34	0.29	3.76	3.30	166.54	169.19	49.10	49.64	170.95	173.13
Cyhalofop-butyl + almix	9.02	7.83	0.73	0.64	7.96	6.91	141.06	149.99	41.60	44.14	144.83	153.78
Fenoxaprop-p-ethyl + almix	5.05	4.24	0.44	0.37	5.19	4.36	161.87	163.49	47.72	48.02	166.14	167.41
Control	17.84	17.29	1.52	1.47	16.25	15.74	99.49	108.55	25.94	28.42	94.39	103.25
SEm ±	0.30	0.16	0.017	0.013	0.19	0.15	1.06	1.82	0.42	0.77	1.30	2.39
CD (P=0.05)	0.66	0.50	0.055	0.042	0.59	0.46	2.35	4.06	0.94	1.71	2.90	5.32
Time of application												
Morning	9.02	8.11	0.71	0.64	7.87	7.08	142.85	148.29	41.51	43.02	145.26	150.64
Afternoon	9.76	8.91	0.83	0.76	9.17	8.36	142.51	146.23	41.56	42.42	145.24	148.52
Evening	8.79	7.92	0.69	0.63	7.65	6.89	143.67	149.37	41.67	43.53	145.91	152.17
SEm ±	0.12	0.13	0.010	0.010	0.11	0.11	0.56	1.00	0.24	0.43	0.71	1.31
CD (P=0.05)	NS	NS	NS	NS	NS	NS	1.15	2.07	0.70	1.24	2.08	3.82
SEm ± (Interaction)	0.30	0.32	0.024	0.025	0.26	0.28	1.37	3.47	0.59	1.04	1.75	3.20
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

and 169.19 kg/ha), P (49.10 and 49.64 kg/ha) and K (170.95 and 173.13 kg/ha) by crop was recorded with pyrazosulfuron-ethyl application due to higher grain and straw yield, and poor weed growth during both the years (Table 5). Mukherjee and Singh (2005) also reported that the hand weeding and chemical treatment with almix + 2, 4 DEE 15 + 500 g/ha significantly increased the nutrient uptake by crop and gave higher grain yields. However, the minimum nutrient uptake by crop was noted under unweeded check at Banaras Hindu University. Lowest nutrient uptake of N (99.49 and 108.55 kg/ha), P (25.94 and 28.42 kg/ha) and K (94.39 and 103.25 kg/ha) was recorded under control plot.

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