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Research Paper

Influence of weed control methods on weeds, yield, energetics and economics of basmati rice (*Oryza sativa*) under sub-mountaineous conditions of Punjab

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ABSTRACT

A field experiment was conducted during the rainy (*kharif*) season of 2011–12 and 2012–13 at Krishi Vigyan Kendra, Gurdaspur to assess the effect of various weed control methods on grain yield, weed control efficiency, energy and economics of basmati rice (*Oryza sativa* L.). The experiment was laid out in randomized block design having 3 replications and comprised of nine treatments, viz. butachlor 50 EC @ 1.5 kg a.i./ha, pretilachlor 50 EC 0.75 kg a.i./ha, pyrazosulfuron ethyl 10 WP @ 15 g a.i./ha, oxadiargyl 80 WP @ 90 g a.i./ha, bispyribac 10 SC @ 25 g a.i./ha, fenoxaprop 6.7 EC @ 67 g a.i./ha, 3 mechanical-weedings with conoweeder (15, 30 and 45 DAT), 2 hand-weedings (15 and 30 DAT) and a weedy check. Mechanical-weeding thrice with conoweeder was significantly superior over all weed control methods for reducing the density and dry-matter accumulation of weeds, increasing the grain yield (3.89 t/ha) and weed control efficiency followed by hand weeding twice. Higher energy productivity (0.44 Kg/MJ) and benefit: cost ratio (1.80) were observed in mechanical weeding thrice with conoweeder. Hand-weeding twice in basmati rice was found to be more energy consuming (9.96 × 10^3 MJ/ha) over other treatments.

Key words **:** Basmati rice, Conoweeder, Energy productivity, Herbicides, Weed control methods

Basmati, the unique aromatic quality rice is a nature's gift to Indian sub-continent. Basmati rice has certain unique characteristics, viz. long-grained, fine texture and aroma, which owe their origin to the genotype and special agro-climatic conditions prevailing in the Indo-Gangetic Plains. Severe weed infestation is a major biotic constraint to rice production. Uncontrolled weeds cause upto 80% reduction in grain yield and sometimes result in complete failure of the crop (Gopinath and Kunder, 2008). Weeds not only compete with rice nursery for growth factors (Rao and Keith, 1988a), but due to morphological similarities, they get transplanted in the field along with rice seedlings (Rao and Keith, 1988b). These weeds also add large number of seeds to the soil as the source of infestation for the subsequent cropping years. In general, hand-weeding and pre-emergence application of herbicides in rice crop are practised to control weeds, but these methods are not responsive as per expectation due to weather and application problems. Thus, new formulation of herbicides as post-emergence and other methods have been tried along with prevalent methods to control weeds in basmati rice.

Manual removal of weeds is labour intensive, tedious, back-breaking and does not ensure weed removal at critical stage of crop-weed competition. Manual weeding is often not done in time due to adverse soil and weather condition. Conoweeder is improved intercultural tool which help in incorporation of weed biomass and maintains proper aeration in soil (Satyanarayana *et al.*, 2007). Weeds get removed and incorporated into the soil with conoweeder. Hence, in the present study, an attempt has been made to assess the effect of various weed control methods on grain yield, weed control efficiency, energy productivity and economics of basmati rice.

MATERIALS AND METHODS

A field experiment was conducted during the rainy (*kharif*) season of 2011–12 and 2012–13 at Instructional Farm, Krishi Vigyan Kendra, Gurdaspur situated between (32°02' N and 75°22' E and 265.17 m above mean sea-level). The experimental site soil was clay loam in texture, medium in organic carbon (0.60%), high in available phosphorus (35.25 kg/ha) and low in potassium (135 kg/ha) at 0-15 cm soil depth. The soil was neutral in *p*H (7.1) with normal electrical conductivity (0.26 ds/m). The experiment was laid out in randomized block design (RBD)

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with 3 replications. The experiment comprised nine treatments, viz. butachlor 50 EC @ 1.5 kg a.i./ha, pretilachlor 50 EC 0.75 kg a.i./ha, pyrazosulfuron ethyl 10 WP @ 15 g a.i./ha, oxadiargyl 80 WP @ 90 g a.i./ha, bispyribac 10 SC @ 25 g a.i./ha, fenoxaprop 6.7 EC @ 67 g a.i./ha, mechanical weeding thrice with conoweeder (15, 30 and 45 days after transplanting), hand-weedings twice (15 and 30 DAT) and a weedy check.

Basmati rice 'PUSA basmati 1121' was sown in nursery during first fortnight of June in both the years. Afterwards, 30 days old seedlings were transplanted 20 cm apart in rows in the first fortnight of July during both the years. All the recommended package of practices except weed control was adopted in the experiment plot during both the years. The crop was fertilized with recommended doses of fertilizers, *viz.* 41.4 kg/ha N and 30 kg/ha K_2O using urea and muriate of potash as a source of fertlizers, respectively. The whole quantity of K_2O was applied at the time of transplanting. Nitrogen was applied in 2 splits. The first close was applied 3 weeks and the second of weeds after transplanting. Need based irrigation was given to the crop.

Herbicidal treatments butachlor 50 EC @ 1.5 kg a.i./ha, pretilachlor 50 EC 0.75 kg a.i./ha, pyrazosulfuron ethyl 10WP @ 15 g a.i./ha, oxadiargyl 80 WP @ 90 g a.i./ha were applied as pre-emergence by mixing with 150 kg of sand/ha and broadcast uniformly in 4–5 cm deep standing water 2–3 DAT at their respective doses as per treatments. While bispyribac 10 SC @ 25 g a.i./ha and fenoxaprop 6.7 EC @ 67 g a.i./ha were sprayed as post-emergence at 20–25 DAT at their respective doses as per treatments. These herbicides were applied with manually operated knapsack sprayer fitted with flat fan nozzle. In the plots under hand-weeding, weeds were removed manually at 15 and 30 DAT. Weeds were removed and incorporated into the soil in mechanical weeding with conoweeder at 15, 30 and 45 DAT. The data on weed density/m^2 and dry matter accumulation of weeds (g/m^2) were recorded at harvest from a quadrate measuring 1×1 m^2. The weeds were counted and removed for recording their biomass. Weed samples were sun dried and later oven dried at 70±1°C upto 48 hours until constant weight was attained. The data were also recorded on yield attributes of basmati. The weed control efficiency (WCE) was calculated by using the following formula (Singh *et al*., 2000).

WCE = (DMC–DMT)/DMC × 100

Where, DMC is dry matter of weeds (g) in weedy check and DMT is dry matter of weeds (g) in a particular treatment.

The crop was manually harvested during the first week of November in both the years. The grain yield data were recorded and adjusted to 14% of moisture content. All data were analyzed statistically. The data on weeds were subjected to square root transformation before statistical analysis. The time used to carry out weeding under different practices was recorded and used for calculating the total energy utilized by the crop for production and energy productivity as per following procedure described by Devasenapathi *et al.* (2009).

Energy productivity (Kg/MJ) = Crop yield (Kg/ha)/ Energy input (MJ/ha)

The input energy was evaluated as direct and indirect, renewable and non-renewable forms. Economics were computed using the prevailing market price of inputs and outputs.

RESULTS AND DISCUSSION

Weed flora and Weed control efficiency

The major weed flora observed in the experimental field included *Echinochloa* species, *Cyperus* spp.,

Table 1. Effect of weed control methods on weed density, dry weight and weed control efficiency in basmati rice at harvest (pooled data of 2 years)

Treatment	Weed density (No/m^2)	Dry weight of weeds (g/m^2)	Weed control efficiency (%)
Butachlor 50 EC, 1.5 kg a.i./ha	11.02 (121.0)	10.52 (110.5)	83.8
Pretilachlor 50 EC 0.75 kg a.i./ha	8.99 (80.0)	7.08 (49.2)	92.8
Pyrazosulfuron ethyl 10 WP 15 g a.i./ha	8.94 (79.1)	6.88 (47.0)	93.1
Oxadiargyl 80 WP 90 g a.i./ha	8.77 (76.0)	6.81 (45.8)	93.3
Bispyribac 10 SC 25 g a.i./ha	8.43 (70.3)	6.86 (46.2)	93.3
Fenoxaprop 6.7 EC 67 g a.i./ha	8.93 (79.0)	6.87 (46.4)	93.2
Mechanical weeding with conoweeder (15, 30, 45DAT)	5.91 (34.2)	4.33 (17.8)	97.4
Hand-weeding (15 and 30 DAT)	7.83 (60.5)	5.67 (31.4)	97.1
Weedy check	23.49 (550.7)	26.2 (685.3)	-
SEm±	0.38	0.41 -	
CD (P=0.05)	1.15	1.21 -	

Figures in parentheses indicate original values and data is transformed to $\sqrt{x+1}$.

Ischaemum rugosum, Digitaria sanguinalis, Caesulia axillaris and *Fimbristylis tenera* L. On an average, weed density of 550.7/m² was recorded in the weedy check plots. All the treatments recorded significant reduction in the density of weeds and biomass of weeds compared with weedy check (Table 1). Mechanical weeding thrice with conoweeder was most effective in reducing the density of weeds and it was significantly superior to all other treatments. Hand-weeding twice was the next best treatment. The weed control efficiency of different weed control measures ranged from 83.8% to 97.4%. Higher weed control efficiency was achieved with mechanical weeding thrice with conoweeder closely followed by hand-weeding twice. However, the lowest weed control efficiency (83.8%) was recorded for the treatment involving Butachlor 50 EC @ 1.5 kg a.i./ha.

Crop growth and yield

All the treatments recorded significantly higher plant height compared with weedy check (Table 2). Mechanical weeding thrice with conoweeder resulted in maximum plant height. However, it was at par with other treatments except weedy check. All the weed control treatments resulted in significant increase in effective tillers/m², panicle length, number of grains/panicle and 1,000-grain weight compared to weedy check. Mechanical weeding thrice with conoweeder recorded significantly higher number of tillers/m², panicle length, number of grains/panicle and 1,000-grains weight compared to all other treatments. Among the weed control treatments, the maximum grain yield was obtained with mechanical weeding thrice with conoweeder (3.89 t/ha), which was closely followed by hand-weedings twice (3.57 t/ha). This might be due to effective control of weeds which in turn significantly increased the number of tillers/m², panicle length, number of grains/panicle and 1,000-grain weight and consequently improved the grain yield (Ramachandra *et al.,* 2012).

Energy utilization pattern

Among weed control methods, hand-weeding twice in basmati crop was found to be more energy consuming 9.96×10^3 MJ/ha over other treatments, because it consumed higher number of labours for weeding (Table 2). There was marginal differences in energy utilization pattern with different weed control methods. The highest energy productivity (0.44 Kg/MJ) was observed with mechanical weeding thrice with conoweeder. This result may be because of better weed control, higher crop yield and comparatively low energy consumption. Tiwari *et al.* (2013) reported the similar results in rice.

Economics

Owing to higher crop yield and timely management of

Table 2. Effect of weed control methods on yield attributes, grain yield, energy productivity and economics of basmati rice (pooled data of 2 years)

Treatment	Plant height (cm)	Effective tillers/m²	Panicle length (cm)	Grains/ panicle (Nos.)	1,000-grain weight (g)	Grain yield (t/ha)			Energy input ($\times 10^3$ MJ/ha)	Energy productivity (kg/MJ)	Cost of cultivation ($\times 10^3$ ₹/ha)	Net returns ($\times 10^3$ ₹/ha)	Benefit: cost ratio
						2011–12	2012–13	Mean					
Butachlor 50 EC, 1.5 kg a.i./ha	99.9	302.7	25.6	133.9	20.3	3.08	3.43	3.26	8.82	0.37	29.3	44.1	1.50
Pretilachlor 50 EC 0.75 kg a.i./ha	100.5	305.3	26.0	136.4	20.4	3.20	3.58	3.39	8.60	0.39	29.4	46.9	1.59
Pyrazosulfuron ethyl 10 WP 15 g a.i./ha	100.7	306.9	26.4	138.1	20.7	3.30	3.73	3.52	8.39	0.42	29.4	49.8	1.69
Oxadiargyl 80 WP 90 g a.i./ha	100.7	306.1	25.8	137.0	20.8	3.33	3.73	3.53	8.41	0.42	29.3	50.1	1.71
Bispyribac 10 SC 25 g a.i./ha	100.5	307.2	26.8	138.2	20.6	3.30	3.75	3.53	8.39	0.42	30.8	48.6	1.58
Fenoxaprop 6.7 EC 67 g a.i./ha	100.7	306.8	26.9	138.0	21.3	3.25	3.65	3.45	8.41	0.41	29.9	47.7	1.59
Mechanical weeding with conoweeder (15, 30, 45 DAT)	101.6	319.2	27.6	143.2	22.0	3.73	4.05	3.89	8.85	0.44	31.2	56.3	1.80
Hand-weedings (15 and 30 DAT)	101.4	310.6	27.1	143.0	21.8	3.35	3.78	3.57	9.96	0.36	34.9	45.4	1.30
Weedy check	80.4	203.0	20.6	98.0	18.4	2.03	2.15	2.09	8.39	0.25	26.7	20.3	0.76
SEm±	0.61	4.09	0.75	3.83	0.64	0.12	0.08	-	-	-	-	-	-
CD (P=0.05)	1.8	12.2	2.0	10.5	1.9	0.36	0.25	-	-	-	-	-	-

weeds with mechanical weeding thrice with conoweeder resulted in attaining maximum net returns (₹ 56,345/ha) and benefit: cost ratio (1.80) over all other weed control methods. The minimum net returns and benefit: cost ratio was associated with weedy check. The lower crop yields in weedy check are the reasons for lower net returns in this treatment.

Based on 2 years' data, it may be concluded that weeds associated with basmati rice in sub-mountaineous area can be effectively managed through mechanical weeding thrice with conoweeder at 15, 30 and 45 DAT. The mechanical weeding with conoweeder was the most effective method in terms of weed control efficiency, higher grain yield and economic returns closely followed by hand weeding twice at 15 and 30 DAT.

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