Short Communication

Integrated weed management in upland rice intercropped in coconut

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Abstract
A field study was conducted during *Kharif* 2017 at Coconut Research Station, Balaramapuram, to standardize an economic weed management strategy for upland rice intercropped in coconut. The study revealed that stale seedbed method recorded significantly lower total weed population, total weed dry weight and higher weed control efficiency, grain yield (2.90 t ha^{-1}), net income (₹ 27,848/-) and B: C ratio (1.48) compared to no stale seedbed method (conventional). Among the weed management methods, penoxsulam @ 20, 25 and 30 g ha^{-1} followed by (fb) either hand weeding (HW) or metsulfuron methyl +chlorimuron ethyl effectively controlled weeds and recorded lower total weed dry weight and higher weed control efficiency at 60 DAS. Penoxsulam @ 25 g ha^{-1} at 10-15 DAS fb HW at 35-40 DAS registered the highest grain yield (3.23 t ha^{-1}), net income (₹ 36,090/-) and B: C ratio (1.63). Integration of stale seedbed method with the broad-spectrum herbicide penoxsulam @ 25 g ha^{-1} at 10-15 DAS fb HW at 35-40 DAS can be recommended as an effective weed management practice in upland rice.

Key words: Metsulfuron methyl + chlorimuron ethyl, Penoxsulam, Stale seedbed, Upland rice.

Rice (O*ryza sativa* L.) is the principal food for more than 50 per cent of the global population and contributes about one-fifth to the total calorie consumption of the world (Singh et al., 2012). To meet food and nutritional requirements, the projected demand for rice by 2030 has been estimated at 904 Mt for the world and 824 Mt for Asian region (Kubo and Purevdorj, 2004). In India, transplanting of rice seedlings/wet seeding in puddled and flooded field is the most common method of rice cultivation. But this method of cultivation has some disadvantages like high requirement of water, labour shortage, deterioration of soil physical properties and environmental pollution. Direct seeded rice (DSR) in uplands avoids puddling practice and transplanting of seedlings. So, direct seeded rice system is the best option to replace conventional method of rice cultivation. In DSR, weeds are the major constraint, limiting their productivity. Weed infestation may cause yield reduction to the extent of 64 per cent in direct seeded rice (Rao et al., 2007). Use of herbicides and hand weeding practices were the common methods to control weeds in direct seeded rice. Because of high wages and scarcity of labour during peak season, hand weeding is becoming less popular nowadays. Use of chemical herbicides alone may not be able to provide effective weed control. Season-long and sustainable weed control cannot be achieved by the use of any single weed management approach because of variation in dormancy and growth habits of weeds (Chauhan, 2012). New generation herbicides which are required at very low doses are more effective in controlling all category weeds and these herbicides are less toxic to mammals and have reduced risk of

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environmental pollution. Stale seedbed (SSB) is a preventive weed control method based on the principle of flushing out germinal weed seeds prior to the planting of the crop, and depleting the seed bank in the surface layer of soil, thereby reducing the weed pressure during crop period. So, integration of various weed management approaches, *viz.,* preventive and herbicidal, is necessary to achieve effective, sustainable and long-term weed control in upland rice. The present study was undertaken with the objective to standardize an economic weed management strategy for upland rice intercropped in coconut.

A field experiment was carried out during *Kharif* (first crop) 2017 (June-September 2017) at Coconut Research Station, Balaramapuram, Thiruvanathapuram, Kerala. The experimental field was situated at 8^0 23' 55.10328" North latitude and 77^0 1' 48.9774" East longitude, at an altitude of 9 m above mean sea level. The experiment was laid out in RBD design (factorial) with a plot size of 5 m x 4 m, in three replications, in the inter row spaces of coconut of more than 50 years age planted at a spacing of 7.6 m x 7.6 m. The first factor comprised of two stale seedbed methods, S_1 - stale seedbed [SSB] with mechanical removal of weeds, and S_2 – No stale seedbed (conventional) and second factor comprised of eight weed management methods *viz*., penoxsulam @ 20 g ha^{-1} at 10-15 days after sowing (DAS) followed by (fb) hand weeding (HW) at 35-40 DAS (m_{1}), penoxsulam @ 25 g ha^{-1} at 10-15 DAS fb HW at 35-40 DAS (m_2), penoxsulam @ 30 g ha^{-1} at 10-15 DAS fb HW at 35-40 DAS (m_3), penoxsulam @ 20 g ha^{-1} at 10-15 DAS fb metsulfuron methyl + chlorimuron ethyl (MM+CE) @ 4 g ha^{-1} at 35-40 DAS (m_4), penoxsulam @ 25 g ha^{-1} at 10-15 DAS fb MM+CE @ 4 g ha^{-1} at 35-40 DAS (m_5), penoxsulam @ 30 g ha^{-1} at 10-15 DAS fb MM+CE @ 4 g ha^{-1} at 35-40 DAS (m_6), HW twice at 15 and 35 DAS (m_7) and weedy check (m_8).

The soil of the experimental site was red sandy loam in texture and acidic in reaction. The soil was medium in available nitrogen (282.8 kg ha^{-1}), high in available phosphorus (36.04 kg ha^{-1}) and low in available potassium (105.6 kg ha^{-1}).

For stale seedbed the experimental land was ploughed twice with garden tiller and the soil was brought to a fine tilth. For no stale seedbed, land was ploughed twice to fine tilth just before sowing of the crop and laid out as per the design. The field was kept undisturbed for 10 days for weed seeds to germinate, then a light raking was given to destroy the germinated seedlings. Land preparation was done in no stale treatment and sowing was done in both the treatments on the same day. A short duration rice variety *Prathyasa* (MO-21), released from Rice Research Station, Moncompu, Kerala was dibbled at a spacing of 20 cm x 10 cm. Dried cow dung was applied @ 5 t ha^{-1} at the time of last ploughing and the recommended dose of fertilizers (60 kg N ha^{-1}, 30 kg P_2O_5 ha^{-1}, 30 kg K_2O ha^{-1}) was applied through urea, Rajphos and muriate of potash. One third of the dose of N and K and full dose of P were applied basally and remaining N and K were applied in equal splits at maximum tillering and panicle initiation stages. Application of early post emergence and post emergence herbicides was done according to the treatments.

Total weed density and biomass were assessed at 30 and 60 DAS by placing a quadrat of size 0.25 m x 0.25 m at two places in each plot, collecting the weeds and counting the number and recording the dry weight. At 30 and 60 DAS, weed control efficiency was also worked out. Data on weed density, weed dry weight and weed control efficiency were subjected to square root transformation. Yield attributes *viz.,* number of panicles m^{-2}, number of spikelets per panicle, per cent filled grains, thousand grain weight and grain yield were recorded at harvest. Weed index was also computed. The net income and benefit cost ratio were calculated.

Weed flora consisted of eight species of broad-leaved weeds *viz., Achyranthes aspera, Acalypha indica, Alternanthera sessilis, Phyllanthus niruri,* *Mimosa pudica, Hemidesmus indicus, Spermacoce ocymoides* and *Oldenlandia umbellata*, six species of grasses, *viz., Dactyloctenium aegyptium, Setaria barbata, Eleusine indica, Oryza sativa f. spontanea, Echinochloa crus-galli* and *Digitaria ciliaris* and two species of sedges *viz.,Scirpus maritimus* and *Cyperus rotundus*. Grasses were the dominant weed flora in the rice field, followed by broad leaved weeds. Sedge population was very low. Such diversity in rice weed flora has been documented by Madhukumar et al. (2013).

Stale seed bed method recorded significantly lower total weed population compared to no SSB (conventional) method at 30 and 60 DAS (Table 1). Stale seedbed method involved land preparation to promote germination of weeds before sowing and the emerged weeds were removed by gentle mechanical raking, thus depleting the weed seed bank in the surface soil layers. This could be the reason for the significant reduction in weed population in SSB compared to no SSB. Singh (2013) also reported significant reduction of weed populations in SSB methods.

All the weed management methods suppressed the growth of all categories of weeds and recorded significantly lower weed population compared to weedy check (Table 1). Penoxsulam @ 20 and 30 g ha^{-1} followed by metsulfuron methyl + chlorimuron ethyl (MM+CE) recorded the lowest total weed population at 30 and 60 DAS, respectively. However, these treatments were comparable with penoxsulam @ 30 g ha^{-1} fb HW at 30 DAS and penoxsulam @ 20 and 25 g ha^{-1} fb HW at 60 DAS indicating that the application of metsulfuron methyl + chlorimuron ethyl or hand weeding could be integrated with penoxsulam for effective control of all categories of weeds in upland rice. This is because of the effective control of weeds by penoxsulam during the initial stages of crop growth, and metsulfuron methyl + chlorimuron ethyl application or HW during the later stages of crop growth. The findings of Mukherjee and Maity (2011) and Hemalatha et al. (2017) are also in agreement with these results.

Interaction effect between SSB methods and weed management methods was found significant at 30 and 60 DAS (Table 2). Stale seedbed combined with

Table 1. Effect of weed management practices on total weed population, total weed dry weight and weed control efficiency

Treatments	Total weed population (No. m^{-2})		Total weed dry weight (g m^{-2})		Weed control efficiency (%)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
A - Stale seed bed methods (S)						
s_1 – SSB with mechanical removal of weeds	32.71 (5.53)	18.08 (3.95)	0.41 (0.59)	4.96 (1.75)	88.71(9.43)	84.00 (8.83)
s_2 - No SSB	40.17 (6.13)	24.21 (4.47)	0.78 (0.74)	6.71 (1.92)	78.45(8.39)	79.48 (8.41)
SEm±	0.108	0.114	0.022	0.201	0.037	0.105
CD (0.05)	0.312	0.332	0.066	NS	0.109	0.305
B - Weed management methods (M)						
m_1 – Penoxulam 20 g ha^{-1} fb HW at 35-45 DAS	24.67 (4.94)	8.67 (2.93)	0.16 (0.41)	2.78 (1.34)	95.20 (9.78)	92.34 (9.59)
m_2 – Penoxsulam 25 g ha^{-1} fb HW at 35-45 DAS	41.50 (6.26)	9.33 (2.99)	0.84 (0.91)	1.79 (1.40)	76.80 (8.78)	94.27 (9.73)
m_3 – Penoxsulam 30 g ha^{-1} fb HW at 35-45 DAS	23.33 (4.82)	17.33 (4.13)	0.27 (0.48)	0.99 (1.14)	92.92 (9.66)	97.20 (9.88)
m_4 – Penoxsulam 20 g ha^{-1} fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}	18.67 (4.29)	13.67 (3.66)	0.24 (0.48)	0.80 (1.09)	93.27 (9.68)	97.41 (9.89)
m_5 – Penoxsulam 25 g ha^{-1} fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}	34.67 (5.87)	14.00 (3.71)	0.29 (0.53)	1.57 (1.26)	92.01 (9.62)	93.82 (9.70)
m_6 – Penoxsulam 30 g ha^{-1} fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}	22.67 (4.74)	6.00 (2.41)	0.13 (0.36)	0.08 (0.76)	96.23 (9.84)	99.74 (10.01)
m_7 - Hand weeding twice (15 and 35 DAS)	46.67 (6.83)	34.67 (5.79)	0.38 (0.60)	7.35 (2.08)	89.44 (9.48)	77.07 (8.73)
m_8 - Weedy check (unweeded control)	79.33 (8.90)	65.50 (8.05)	2.42 (1.51)	31.32 (5.61)	32.77 (4.42)	2.06 (1.41)
SEm±	0.215	0.229	0.045	0.402	0.075	0.21
CD (0.05)	0.624	0.664	0.132	1.168	0.217	0.61

NS - Non significant; The figures were subjected to square root transformation$\sqrt{(x+0.5)}$ and transformed values are given in parentheses

Table 2. Interaction effect of SSB methods and weed management methods on total weed population, total weed dry weight and weed control efficiency

Interactions	Weed population (No. m^{-2})		Total weed dry weight (g m^{-2})		Weed control efficiency (%)	
(S x M)	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
$\sigma_1\mu_1$	25.33 (5.02)	8.00 (2.83)	0.15 (0.39)	0.12 (0.79)	95.35 (9.79)	99.63 (10.01)
$\sigma_1\mu_2$	25.67 (4.96)	12.00 (3.43)	0.66 (0.81)	2.63 (1.62)	81.67 (9.06)	91.52 (9.59)
$\sigma_1\mu_3$	25.33 (5.02)	14.67 (3.80)	0.34 (0.51)	1.57 (1.35)	91.86 (9.61)	95.68 (9.81)
$\sigma_1\mu_4$	16.00 (3.98)	11.33 (3.35)	0.35 (0.58)	0.53 (1.01)	90.65 (9.55)	98.06 (9.93)
$\sigma_1\mu_5$	32.00 (5.65)	13.33 (3.64)	0.20 (0.45)	2.93 (1.69)	94.23 (9.73)	88.22 (9.39)
$\sigma_1\mu_6$	18.67 (4.32)	5.33 (2.28)	0.10 (0.30)	0.12 (0.79)	97.51 (9.90)	99.64 (10.01)
$\sigma_1\mu_7$	45.33 (6.73)	24.00 (4.85)	0.26 (0.51)	1.18 (1.22)	92.87 (9.66)	95.13 (9.78)
$\sigma_1\mu_8$	73.33 (8.56)	56.00 (7.44)	1.28 (1.13)	30.61 (5.55)	65.54 (8.12)	4.11 (2.11)
$\sigma_2\mu_1$	24.00 (4.87)	9.33 (3.03)	0.18 (0.43)	5.43 (1.89)	95.05 (9.78)	85.04 (9.18)
$\sigma_2\mu_2$	57.33 (7.57)	6.67 (2.55)	1.02 (1.01)	0.94 (1.19)	71.92 (8.51)	97.02 (9.88)
$\sigma_2\mu_3$	21.33 (4.61)	20.00 (4.46)	0.20 (0.46)	0.40 (0.94)	93.98 (9.72)	98.73 (9.96)
$\sigma_2\mu_4$	21.33 (4.60)	16.00 (3.98)	0.14 (0.37)	1.07 (1.18)	95.88 (9.82)	96.77 (9.86)
$\sigma_2\mu_5$	37.33 (6.09)	14.67 (3.77)	0.36 (0.61)	0.21 (0.84)	89.79 (9.50)	99.42 (10.00)
$\sigma_2\mu_6$	26.67 (5.16)	6.67 (2.55)	0.19 (0.43)	0.04 (0.74)	94.94 (9.77)	99.83 (10.02)
$\sigma_2\mu_7$	48.00 (6.92)	45.33 (6.73)	0.49 (0.70)	13.53 (2.94)	86.02 (9.30)	59.00 (7.68)
s_2m_8	85.33 (9.23)	75.00 (8.66)	3.58 (1.89)	32.03 (5.67)	0.00 (0.71)	0.0 (0.71)
SEm±	0.304	0.323	0.064	0.569	0.106	0.297
CD (0.05)	0.882	0.939	0.187	NS	0.308	0.862

NS - Non significant. The figures were subjected to square root transformation $\sqrt{(x+0.5)}$ and transformed values are given in parentheses

application of penoxsulam fb either MM+CE or HW significantly reduced the population of all categories of weeds. Corroboratory results on the effectiveness of SSB combined with herbicide in controlling weeds was also reported by Bhurer et al. (2013).

The total dry weight of weeds was significantly influenced by SSB methods at 30 DAS (Table 1). Stale seedbed method registered significantly lower total dry weight of weeds compared to no SSB method at 30 DAS. In SSB, first flushes of weeds were removed before sowing the rice crop, thus depleting the weed seed bank. This might be the reason for SSB registering significantly lower dry weight of weeds compared to no SSB. Pandey et al. (2009) also observed similar reduction of dry weight of weeds in SSB compared to normal sowing.

Weed management methods exerted significant effect on total dry weight of weeds at 30 and 60 DAS (Table 1). All the herbicidal treatments and the control treatment HWT significantly reduced the total dry weight of weeds at 30 and 60 DAS compared to weedy check. Penoxsulam @ 30 g ha^{-1} fb MM+CE recorded the lowest total weed dry weight at both stages of observation. At 60 DAS, all the penoxsulam treatments *i.e.,* penoxsulam @ 20, 25 and 30 g ha^{-1} fb either MM+CE or HW were very effective in reducing the total weed dry weight indicating the effectiveness of the post-emergence herbicide penoxsulam in reducing the weed problem in upland rice. Weedy check registered the highest total dry weight of weeds (2.42 g m^{-2} and 31.32 g m^{-2}) at 30 and 60 DAS respectively. The effectiveness of application of penoxsulam at 10 DAS fb HW at 35 DAS in reducing the total weed dry weight in dry direct seeded rice was also reported by Sanodiya and Singh (2017). Similar findings on the effectiveness of penoxsulam in reducing the weed dry weight were reported by Khaliq et al. (2014).

Interaction between SSB methods and weed management methods was found to be significant only at 30 DAS (Table 2). At 30 DAS, the treatment combination SSB with penoxsulam @ 30 g ha^{-1} at 10-15 DAS fb MM+CE @ 4 g ha^{-1} at 35-40 DAS registered the lowest total weed dry weight (0.10 g m^{-2}) and it was statistically comparable with s_2m_4, s_1m_1,s_2m_1, s_2m_6, s_1m_5 and s_2m_3.

Stale seedbed method registered significantly higher weed control efficiency (WCE) (88.71 and 84.00 per cent) compared to no SSB method at 30 and 60 DAS respectively, further emphasizing the effectiveness of SSB in reducing the dry weight of weeds. Higher weed growth and dry matter accumulation in no SSB resulted in poor WCE in these treatments.

Among the weed management methods, penoxsulam @ 30 g ha^{-1} fb MM+CE recorded the highest WCE at 30 and 60 DAS and it was on par with other herbicidal treatments except m_2 at 30 DAS. All the tested doses of penoxsulam, fb either HW or MM+CE treatments effectively controlled the weeds which resulted in lower total weed population and dry weight, thus resulting in high WCE. Weedy check treatment recorded significantly lower WCE due to poor control of weed infestation, resulting in higher weed population and dry weight. Similar findings on the better WCE of penoxsulam were reported by Singh et al.(2016), Netam et al. (2018) and Sanodiya and Singh (2017). Stale seedbed with penoxsulam fb either HW or MM+CE was found to be effective in realising higher WCE at 60 DAS as the combined action of SSB and herbicide action effectively controlled weeds and recorded lower dry weight of weeds.

Stale seedbed methods significantly influenced the yield attributes *viz.,* spikelets per panicle, per cent filled grains and thousand grain weight (Tables 3 and 4). Stale seedbed method recorded significantly higher values for all these yield attributes compared to no SSB. Dry matter production was also significantly higher for SSB compared to no SSB, thus contributing to better expression of yield attributes in SSB. Similar findings were reported by Marahatta et al. (2017).Weed management methods also significantly influenced the yield attributes. Penoxsulam @ 20, 25 and 30 g ha^{-1} fb HW treatments recorded significantly higher values for yield attributes like per cent filled grains and thousand grain weight. This is due to the effective control of weeds, resulting in lesser competition, which allowed better expression of yield attributes in rice. Netam et al. (2018) also reported better expression of yield attributes like thousand grain

Table 3. Effect of weed management practices on yield attributes, grain yield and weed index

Treatments	Panicles m^{-2}	Spikelets per panicle	Per cent filled grains	Thousand grain weight (g)	Grain yield (t ha^{-1})	Weed index (%)
A - Stale seed bed methods (S)						
s_1 – SSB with mechanical removal of weeds	272.1	77.83	84.99	27.44	2.90	18.44 (3.93)
s_2 - No SSB	260.8	71.80	81.14	26.93	2.57	27.61 (5.08)
SEm±	4.462	1.073	0.408	0.148	0.046	0.174
CD (0.05)	NS	3.113	3.313	0.432	0.134	0.506
B - Weed management methods (M)						
m_1 – Penoxulam 20 g ha^{-1} fb HW at 35-45 DAS	295.3	84.03	85.81	27.64	3.05	14.24 (3.51)
m_2 – Penoxsulam 25 g ha^{-1} fb HW at 35-45 DAS	265.3	77.67	86.97	28.09	3.23	8.98 (2.46)
m_3 – Penoxsulam 30 g ha^{-1} fb HW at 35-45 DAS	284.0	81.40	84.13	27.86	3.04	14.34 (3.80)
m_4 – Penoxsulam 20 g ha^{-1} fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}	301.3	68.20	80.32	27.05	2.8	21.31 (4.61)
m_5 – Penoxsulam 25 g ha^{-1} fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}	307.0	70.73	85.61	26.63	2.94	17.16 (4.20)
m_6 – Penoxsulam 30 g ha^{-1} fb metsulfuron methyl + chlorimuron ethyl 4 g ha^{-1}	306.0	78.16	85.74	27.41	2.82	20.60 (4.44)
m_7 - Hand weeding twice (15 and 35 DAS)	219.3	80.50	83.18	27.38	2.6	26.85 (5.20)
m_8 - Weedy check (unweeded control)	153.3	57.70	72.77	25.43	1.4	60.70 (7.82)
SEm±	8.924	2.146	2.282	0.297	0.093	0.349
CD (0.05)	25.899	6.227	6.625	0.864	0.269	1.013

NS - Non significant, Values in parentheses are transformed values, data were subjected to square root transformation $\sqrt{(x+0.5)}$

weight and number of grains per panicle by the application of penoxsulam fb HW. Similar findings was also reported by Singh et al. (2016).

Stale seedbed methods significantly influenced the grain yield of upland rice. Compared to no SSB (s_2) with a grain yield of 2.57 t ha^{-1}, SSB (s_1) recorded significantly higher grain yield of 2.90 t ha^{-1}.

Penoxsulam @ 25 g ha^{-1} fb HW (m_2) registered the highest grain yield and it was on par with penoxsulam fb HW treatments (m_1 and m_3). These treatments were found to be significantly superior to penoxsulam fb MM+CE and HWT treatments. Even though total weed density, dry weight and WCE were comparable to that for penoxsulam fb MM+CE treatments, it was not manifested in grain yield, probably as these treatments were not at all effective in controlling new flushes of grasses. However, compared to weedy checkm all the weed control treatments (penoxsulam @ 20, 25 and 30 g ha^{-1} fb either HW or MM+CE and HWT) recorded significantly higher grain yield. These results are in close conformity with the findings of Netam et al. (2018) and Sanodiya and Singh (2017).

Weed index which indicates the percentage yield reduction due to weeds, was also influenced by SSB methods and significantly lower weed index was observed in SSB compared to no SSB. Among the weed management methods, penoxsulam @ 25 g ha^{-1}fb HW treatment recorded the lowest weed index, and was significantly superior to all other weed management methods. Weedy check treatment recorded yield reduction of rice upto 60.70 per cent. The treatment combination s_1m_1 (SSB with penoxsulam @ 20 g ha^{-1}fb HW) registered the lowest weed index.

Stale seedbed method registered substantially higher net income (₹ 27,848/-) and B: C ratio (1.48) compared to no SSB method (Table 5). Even though the cost involved for preparing SSB was higher (^{1} 7100 ha^{-1}) than no SSB (₹ 2840 ha^{-1}) better control of weeds resulting in higher grain yield (2.90 t ha^{-1}) compensated for it, resulting in substantially high net income and B: C ratio. Pandey et al. (2009) reported that SSB method recorded higher net returns compared to traditional seedbed.

All the herbicidal treatments recorded higher net income and B:C ratio compared to hand weeding twice. Penoxsulam @ 25 g ha^{-1} fb HW recorded the highest net income (₹ 36,090/-) and B:C ratio (1.63). In penoxsulam fb HW treatments, the labour used for weeding was comparatively less because the broad-spectrum herbicide penoxsulam effectively controlled weeds and the number late emerging weeds was very low, resulting in less cost for penoxsulam fb HW treatments. The highest grain yield and lower labour cost for HW in penoxsulam fb HW treatment might be the reason for obtaining the highest net income and B:C ratio. Netam et al. (2016) and Sanodiya and Singh (2017) also reported similar results.

Integration of SSB with penoxsulam @ 25 g ha^{-1} fb HW registered the highest net income (₹ 44,433/-) and B:C ratio (1.77). Combination of SSB method with herbicidal treatment effectively controlled weeds which resulted in higher grain yield of rice (Table 6). This could be the reason for realizing the highest net income and B: C ratio. Chaudhary et al. (2006) pointed out that energy utilization for HW practice in dry upland rice crop was lower under SSB (690 MJ ha^{-1}) than under traditional seedbed (925 MJ ha^{-1}).

Based on grain yield, weed index and economic analysis, integration of stale seedbed method with the broad-spectrum herbicide penoxsulam @ 25 g ha^{-1} at 10-15 DAS fb HW at 35-40 DAS can be recommended as an economic and effective weed management practice in upland rice.

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