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THE MANUAL, CHEMICAL, CULTURAL, AND INTEGRATED WEED MANAGEMENT IN SOYBEAN PRODUCTION

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ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka, from December 2021 to April 2022 to study the effect of weed management practices in soybean (*Glycine max* L.). The experiment was laid out in a Randomized three-Complete Block Design (RCBD) with twelve weed management treatments- no weeding (Control), two hand weeding (at 15 and 30 DAS), pre-emergence herbicide (Herbilin 33% EC @ 400 ml ha^{-1}), post-emergence herbicide Irish EC @ 1200 ml ha^{-1}, pre + post-emergence herbicide, pre-emergence + 1 hand weeding {40 days after sowing (DAS)}, post-emergence herbicide + 1 hand weeding (40 DAS), pre + post-emergence herbicide + 1 hand weeding(40 DAS), straw mulching, intercrop with *Amaranthus dubius*, and *Zea mays*, and weed-free. The experimental result showed among seven different weed species found, *Cyperus rotundus* was the most prevalent weed, with the highest weed density (123 and 128.67 m^{-2}) and relative weed emergence (43.16 and 38.79 %) in the control plot at 30 and 60 DAS. The treatment pre + post-emergence herbicide + 1 hand weeding (40 DAS) showed the longest pod length (4.16 cm) and number of seeds pod^{-1} (3.89). The weed-free treatment resulted in the highest 1000-seed weight (111.00 g), seed yield (1.86 t ha^{-1}), stover yield (2.16 t ha^{-1}), biological yield (4.03t ha^{-1}), and harvest index (46.35 %). However, the highest benefit-cost ratio (2.85) was obtained under post-emergence herbicide (Irish EC) treatment. Therefore, applying Irish EC was the best broad-spectrum effective herbicide to manage the various weed floras in soybeans for profit.

Keywords: Soybean, Weed management, Herbicide, Yield, Benefit-cost ratio

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INTRODUCTION

Soybean (*Glycine max* (L.) Merrill) is the most widely cultivated legume around the world because of its versatile uses and economic importance (Liu et al., 2020). It is one of the most multipurpose, nutritionally, and economically important legumes due to its unique seed composition (Shea et al., 2020). Soybean seed contains about 18 to 22% oil and 38 to 56% vegetable protein with favorable amino acids (USDA, 2023). It is a prominent source of proteins and edible oil and has practical uses as food, feed, and oil seed crop (Liu et al., 2020). Globally, soybean accounts for about 61% of international oilseed production, occupying 6% of the world's cultivable area (Soy Stat, 2022).

Soybean oil has gained popularity in Bangladesh (Khanam et al., 2016). However, as oil extraction is not yet possible using traditional methods in Bangladesh, the soybean is predominantly used in the feed industries, and all soybean oil found in the market is imported ones. In Bangladesh, soyabean was cultivated in 57646.26 hectares, and the production was 91176.59 tons, while demand of soyabean mainly for poultry feed was 1.8-2 million tons in 2021 (BBS, 2021).

Soybean's low productivity is attributed mainly to biotic and abiotic stresses, *viz.*, weeds, insect pests, and disease (Chaudhari et al., 2020). One of the main challenges restricting the global output of soybeans is weeds. Physically, soybeans are small, and their initial growth is slow, which makes them susceptible to weed interference. Sandil et al. (2015) reported that weeds alone reduce soybean yield by 25%-70%, depending on the weed flora and intensity. Keeping weeds out of the soybean crop from 13 to 44 DAE is necessary to prevent yield losses of more than 2.5% (Halford et al., 2001). Mohammadi and Amiri (2011) determined the critical weed-free period (CWFP) for a <5% yield loss in soybeans is 9 to 47 DAE. According to the Weed Science Society of America's yield loss committee, soybean growers in the United States and Canada would lose an average of 52% of their soybean grain production, worth US$17.2 billion per year, if weeds are not controlled (Soltani et al., 2017).

Hand weeding is a traditional and effective method of weed control. Still, untimely continuous rains during critical weed competition periods, unavailability of labor at peak times, and increased labor wages are the main limitations of manual weeding. Chemical weed control has been a primary means of weed management in the developed world for the past six decades. In Bangladesh, most farmers use pre- and post-emergence herbicides for weed control, but their efficacy is reduced by various climatic and edaphic factors (Ahmed and Chauhan, 2014). The herbicides presently available are either pre-emergence (PE) or pre-plant incorporated (PPI) and have a narrow spectrum of weed control (Chaudhari et al., 2020).

Integrated Weed Management (IWM) is a comprehensive method to control and mitigate weed infestation in fields incorporating diverse techniques. Many weeds have different life cycles; thus, a single control method is ineffective. Hence, this study was conducted to learn which weed management techniques would be effective in terms of soybean output.

MATERIALS AND METHODS

The experiment was conducted at Sher-e-Bangla Agricultural University. The experimental site is 8.6 meters above sea level. Seeds of soybean were sown on 26 December 2021 and harvested on 10 April 2022. The cropping temperature ranged from 13.1°C to 34.1°C, the humidity from 58% to 80% with 10.5-11.0 hours day length, with a little rainfall (avg. 72 mm). The soil (26% sand, 45% silt, 29% clay, textural class: silty-clay, pH 5.6, % organic carbon 0.45, %N 0.03, P 20.54 ppm, K 0.10 mg per 100 g soil, and S 45 ppm) of experimental plots was slightly acidic in reaction with low organic matter (0.78%). The Binasoybean-2 variety was used.

This was a single factor experiment comprising manual, chemical, cultural, and integrated weed management with 12 treatment composition as T_1: No weeding (Control), T_2: Two-hand weeding (at 15 and 30 DAS), T_3: Pre-emergence herbicide Herbilin 33% EC [N-(l-ethylpropyl)-3, 4-dimethyl 1, 2, 6Dinitrobenzenamine] @ 400 ml ha^{-1}), T_4: Post-emergence herbicide Irish (Sodium Acifluorfen 16.5% + Clodinafop Propargyl 8% EC) @ 1200 ml ha^{-1}, T_5: Pre (Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_6: Pre-emergence (Herbilin 33% EC @ 400 ml ha^{-1}) + 1 hand weeding (40 DAS), T_7: Post-emergence (Irish @ 1200 ml ha^{-1}) + 1 hand weeding (40 DAS, T_8: Pre + Post-emergence + 1 hand weeding (40 DAS), T_9: Straw mulching, T_{10}: Intercrop with red amaranth, T_{11}: Intercrop with maize and T_{12}: Weed-free (hand hoeing until harvest). The experiment was laid out in a randomized complete block design with three replications. The plot size was 5.4 m^2 (2.7 m × 2 m). The blocks and plots were separated by 1.0 m and 0.50 m spacing. Urea, TSP, MoP, Gypsum, and boric acid, as the source of Nitrogen, Phosphorus, Potassium, Sulphur, and Boron, respectively, were applied @ 50, 150, 100, 80, and 8 kg ha^{-1} according to BARI, 2019. Seeds were sown by dibbling in soil. The dribbling was done by maintaining a 45 cm inter-row and 5 cm intra-row distance and a 30 cm inter-row and 10 cm intra-row distance. It was done on 26 December 2021. Two irrigations were given. 1^{st} irrigation was given at 25 DAS, whereas the second irrigation was given at 55 DAS. Maize was grown as a green fodder crop and harvested on 19 February 2022 (Fig. 1A). Red amaranth leaves were harvested on 19 February 2022 when they were big enough to eat (Fig. 1B).

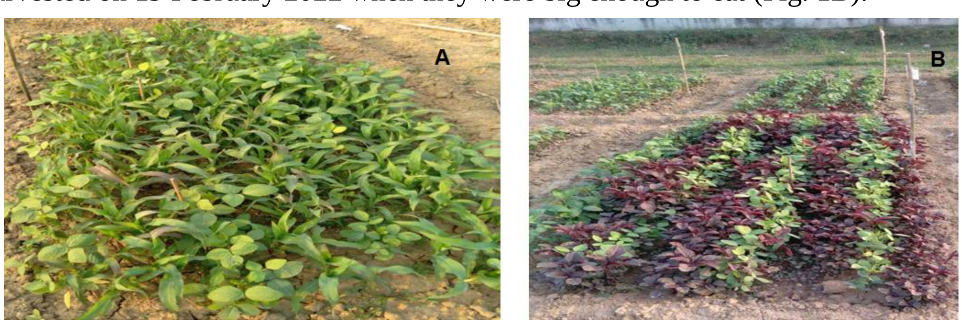

Figure 1. Growing of maize (A) and red amaranth (B) as intercrop with soybean

The maturity of the soybean was determined when 95% of the pods became brown. Five sample plants were collected from each plot before harvesting to take yield attribute data. The central 1 m^2 area plants were harvested by placing quadrates for recording yield data. The data collected on weed control, growth, yield parameters, and yield were statistically analyzed to obtain the level of significance by using Statistix10 Data analysis software. The mean differences were adjudged by the Least Significant Difference (LSD) test at a 5% probability level (Lee and Lee, 2018). The economic performance of different treatment combinations was determined on a $hectare^{-1}$ area basis, which includes the total cost of production, gross returns, net returns, and benefit-cost ratio (profit over per taka investment) under treatments imposed.

RESULTS AND DISCUSSION

Weed flora

Seven different weed species were observed in the experimental field, with sedge, grass, and broadleaf weed species dominating (Table 1). Among the infesting different categories of weed species, two were grasses, one sedge, and four broadleaves. The weed species belonged to Labiatae, Poaceae, Boraginaceae, Asteraceae, Amaranthaceae, and Cyperaceae families. The grasses were *Echinochloa colona, and Cynodon dactylon.* The sedge was *Cyperus rotundus*, and the broadleaf was *Alternanthera philoxeroides. Brassica kaber*, *Heliotropium indicum*, and *Enydra fluctuans.* The result obtained from the present study was similar to the findings of Chander et al. (2013), who reported that the field of soybean was infested with *Commelina benghalensis, E. colona, Aeschynomene indica, Ageratum conzoides, Panicum dichotomiflorum, Digitaria saniguinalis, Eleusine indica, and C. rotundus.*

Table 1 shows species-specific weed density (m^{-2}) and relative weeds emergence (%) of weeds recorded in weedy check plots at 30 and 60 DAS. The experimental result clearly shows that sedge and grass weeds predominated in weedy check plots of the soybean field. *C. rotundus* was the most prevalent weed, with the highest weed density (123 and 128.67 m^{-2}) and relative weed emergence (43.16 and 38.79 %) in the weedy check plot at 30 and 60 DAS, followed by *E. colona* and *C. dactylon*. At the same time, the dominance of *H. indicum* and *A. philoxeroides* was lowest among all weed species in the weedy check plot at 30 and 60 DAS. The result was similar to the findings of Panda et al. (2015), who reported that the grassy weeds were predominant in the soybean experimental field compared with broad-leaf weeds.

Table 1. Weed flora, weed density, and relative weeds emergence (%) in the soybean field during the experiment

Scientific name	Family	Type	Weed density (No. m^{-2})		Relative weeds emergence (%)	
			30 DAS	60 DAS	30 DAS	60 DAS
Cyperus rotundus	Cyperaceae	Sedge	123	128.67	43.16	38.79
Echinochloa colona	Poaceae	Grass	48	65.33	16.84	19.7
Cynodon dactylon	Poaceae	Grass	44.67	50.33	15.67	15.17
Enydra fluctuans	Asteraceae	Broadleaf	35.67	41	12.51	12.36
Brassica kaber	Brassicaceae	Broadleaf	13.67	17.67	4.8	5.33
Alternanthera philoxeroides	Amaranthaceae	Broadleaf	12	15.67	4.21	4.73
Heliotropium indicum	Boraginaceae	Broadleaf	8	13	2.81	3.92

Plant height (cm)

Plant height is an important morphological character that is a potential indicator of the availability of growth resources in its approach. The experiment results demonstrated that soybean plant height varied significantly due to the effect of different weed management practices (Figure 2). The highest plant height (13.19 cm) was observed in pre + post-emergence herbicide + 1 hand weeding (40 DAS) treatment at 15 DAS; at 30 DAS from straw mulching treatment (20.08 cm); at 45 DAS from intercrop with maize treatment (30.97 cm); at 60 DAS from intercrop with maize treatment (42.41 cm); at 75 DAS from intercrop with red amaranth treatment (53.98 cm) and at harvest from pre-emergence herbicide + 1 hand weeding (40 DAS) treatment (46.41 cm). While the lowest plant height (10.13 cm) was found in pre-emergence herbicide (Herbilin 33% EC @ 400 ml ha^{-1}) treatment at 15 DAS; at 30 DAS from in pre + post-emergence herbicide + 1 hand weeding (40 DAS) treatment (16.37 cm); at 45 DAS from pre + post-emergence herbicide treatment (23.38 cm); at 60 DAS from intercrop with red amaranth treatment (32.09 cm); at 75 DAS from intercrop with red amaranth treatment (32.71 cm) and at harvest from straw mulching treatment (38.87 cm). The variation in plant height may be due to the adaptation of different weed management practices. Jadhav (2013) reported that integrated weed management treatments, i.e., quizalofopethyl 0.05 kg ha^{-1} and chlorimuron-ethyl 0.009 kg ha^{-1}as post-emergence at 15 DAS + hand weeding at 30 DAS, recorded significantly higher plant height which was at par with the weed-free check.

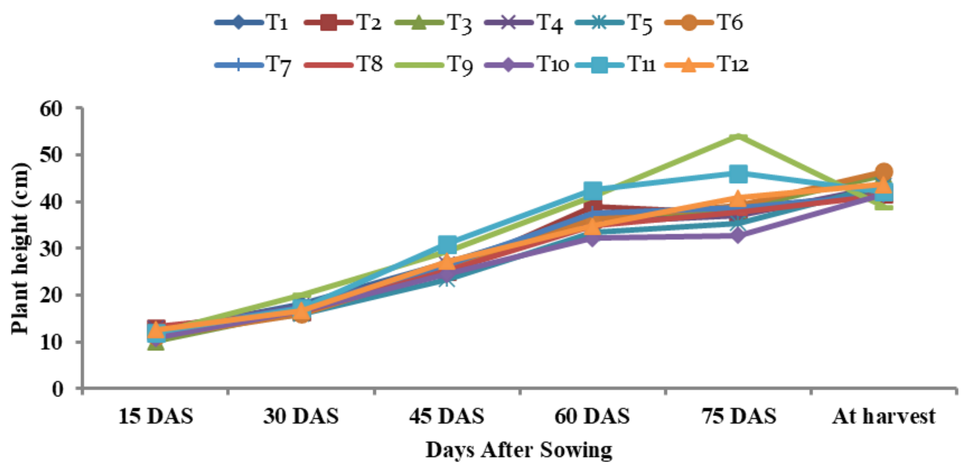

Figure 2. Effect of manual, chemical, cultural, and integrated weed managements on plant height of soybean at different DAS

Here, T_1: No weeding (Control), T_2: Two hand weeding (15 and 30 DAS), T_3: Pre-emergence herbicide (Herbilin 33% EC @ 400 ml ha^{-1}), T_4: Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_5: Pre (Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_6: Pre-emergence(Herbilin 33% EC @ 400 ml ha^{-1}) + 1 hand weeding (40 DAS), T_7: Post-emergence(Irish @ 1200 ml ha^{-1}) + 1 hand weeding (40 DAS, T_8: Pre(Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}) + 1 hand weeding(40 DAS), T_9: Straw mulching, T_{10}: Intercrop with red amaranth, T_{11}: Intercrop with maize and T_{12}: Weed-free.

The number of Pods plant^{-1}

Different weed management treatments have significantly influenced the number of pods plant^{-1} of soybean (Table 1). The highest number of pods plant^{-1} of soybean (28.79) was found in the two hand weeding (15 and 30 DAS) treatment. However, the treatment pre + post-emergence herbicide + 1 hand weeding (40 DAS) had the lowest (18.67) number of pods plant^{-1} of soybean. This might be due to reduced weed growth and population by different weed management treatments at different stages. This ultimately lowers competition by weeds with the crop for moisture and nutrients, thus increasing the number of pods plant^{-1} of soybean. Kumar et al. (2019) also found similar result who reported that in the case of greengram, the highest pods plant^{-1} was recorded under two HW at 20 and 40 DAS, which was on par with manual weeding at 25 DAS.

Pod length (cm)

Different weed management treatments significantly affected pod length plant^{-1} of soybean (Table 1. The experimental result showed that the highest pod length plant^{-1} (4.16 cm) was observed in the treatment pre + post-emergence herbicide + 1 hand weeding (40 DAS). On the other hand, the shortest pod length (3.58 cm) was found in the post-emergence herbicide (Irish @ 1200 ml ha^{-1}) treatment. The results revealed that weed management directly affected increasing the pod length of soybeans. With a decreasing weed population, pod length plant^{-1} increased in soybean because of higher absorption of nutrients and water from the soil. As a result, the activity of cell division increased. This favored more vegetative growth and produced more dry matter accumulations in soybean plants, thus increasing the pod length of soybean. A similar result was observed by Peer et al. (2013), who reported that all the weed control treatments significantly influenced the yield-contributing characteristics of soybeans, including pod length.

Number of Seeds pod^{-1}

Various weed management treatments significantly influenced the number of seed pod^{-1} of soybeans (Table 1). According to the results of the experiment, the pre + post-emergence herbicide + 1 hand weeding (40 DAS) treatment had the highest seeds pod^{-1} (3.89). On the other hand, the treatment post-emergence herbicide (Irish @ 1200 ml ha^{-1}) had the lowest seeds pod^{-1} (3.00). Jadhav et al. (2013) reported that in weed management treatments, i.e., quizalofopethyl 0.05 kg ha^{-1}and chlorimuron-ethyl 0.009 kg ha^{-1} as post-emergence at 15 DAS + hand weeding at 30 DAS, recorded significantly had higher seeds pod^{-1} which was at par with the weed-free check. Peer et al. (2013) reported that integrated use of herbicides and cultural management gave better seed yield and yield attributed than their sole application.

1000-seed weight (g)

The weight of 1000- seeds varied significantly due to weed control methods (Table 1). The weed-free treatment had the highest (111.00 g) 1000-seed weight. On the other hand, straw mulching had the lowest (98.33 g) 1000-seed weight. The result was similar to the findings of Yadav (2016). They reported that the yield contributing characteristics like the number of seeds pod^{-1}, number of pods plant^{-1}, the weight of pods plant^{-1}, 1000-seed weight, seed, and stover yield were found significantly superior in weed-free check followed by pendimethalin @ 1 kg a.i. ha^{-1}fb.one hoeing at 30 DAS.

Table 1. Effect of manual, chemical, cultural, and integrated weed managements on yield contributing parameters and yield of soybean

Treatments	Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	1000-seed weight (g)	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})
T_1	22.00 ab	3.99 ab	3.33 a-c	105.00 bc	0.51 h	1.38 e
T_2	28.79 a	3.84 ab	3.44 a-c	104.00 c	1.29 b-e	1.62 c-e
T_3	22.00 ab	3.90 ab	3.22 a-c	105.00 bc	1.37 b-d	2.13 ab
T_4	24.44 ab	3.58 b	3.00 c	110.33 a	1.44 bc	2.04 a-c
T_5	22.33 ab	3.91 ab	3.33 a-c	104.33 c	1.04 d-g	1.65 c-e
T_6	23.44 ab	3.94 ab	3.78 ab	109.33 ab	1.26 c-f	1.69 b-e
T_7	21.56 ab	3.98 ab	3.11 bc	106.67 a-c	0.95 fg	1.65 c-e
T_8	18.67 b	4.16 a	3.89 a	105.33 bc	1.63 ab	1.93 a-d
T_9	20.22 b	3.98 ab	3.33 a-c	98.33 d	1.03 e-g	1.40 e
T_{10}	21.00 b	3.61 b	3.11 bc	103.00 cd	0.79 gh	1.59 de
T_{11}	20.33 b	3.84 ab	3.33 a-c	99.00 d	1.17 c-f	1.36 e
T_{12}	22.33 ab	3.63 b	3.67 a-c	111.00 a	1.86 a	2.16 a
$LSD_{(0.05)}$	7.30	0.48	0.69	4.83	0.34	0.44
CV(%)	19.39	7.45	12.19	2.72	16.69	15.36

A column means having a similar letter(s) are statistically similar, and those having dissimilar letter(s) differ significantly at 0.05 probability level.

Here, T_1: No weeding (Control), T_2: Two hand weeding (15 and 30 DAS), T_3: Pre-emergence herbicide (Herbilin 33% EC @ 400 ml ha^{-1}), T_4: Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_5: Pre (Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_6: Pre-emergence(Herbilin 33% EC @ 400 ml ha^{-1}) + 1 hand weeding (40 DAS), T_7: Post-emergence(Irish @ 1200 ml ha^{-1}) + 1 hand weeding (40 DAS, T_8: Pre(Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}) + 1 hand weeding(40 DAS), T_9: Straw mulching, T_{10}: Intercrop with red amaranth, T_{11}: Intercrop with maize and T_{12}: Weed-free.

Seed yield (kg ha^{-1})

Due to different weed management treatments, soybean seed yield was significantly influenced (Table 1). The highest seed yield (1.86 t ha^{-1}) was observed in the weed-free treatment, which was statistically similar to the pre + post-emergence + 1 hand weeding(40 DAS) treatment(1.63 t ha^{-1}). The lowest seed yield (0.51 t ha^{-1}) was observed in the no weeding treatment (Table 1). The differences in yield among different treatments might be due to a reduction in weed growth and the population at various stages of weed management techniques, which lower competition by weeds with the crop for moisture and nutrients. Suryavanshi et al. (2015) reported that the highest yield attributing traits and yields were recorded in the weed-free situation.

Still, these parameters were found statistically at par with the application of pendimethalin 0.75 kg ha^{-1} (PE) + one hoeing at 30 DAS followed by hand weeding at 40 Days after sowing and application of Pendimethalin 1.0 kg ha^{-1}(PE) + Quizalofop-ethyl 37.5 g ha^{-1} at 20 DAS. Jha et al. (2014) reported that the weed-free check was found to be the best by recording soybean's highest nodulation, yield, and yield attributes.

Stover yield (kg ha^{-1})

Different weed management treatments have significantly affected the soybean's stover yield (Table 1). The weed-free treatment recorded the highest stover yield (2.16 t ha^{-1}), which was statistically similar to pre + post-emergence + 1 hand weeding (40 DAS) (1.93 t ha^{-1}), post-emergence herbicide, (Irish @ 1200 ml ha^{-1}) (2.04 t ha^{-1}), and T_3 (2.13 t ha^{-1}) treatment. On the other hand, the no weeding treatment recorded the lowest soybean stover yield (1.38 t ha^{-1}). Different weed management strategies lowered weed density, which aided undisturbed plant growth by exploiting its surrounding resources, resulting in differences in stover production over the control treatment. Kulal et al. (2017) also found similar results that supported the present finding and reported that all the weed control treatments showed significantly higher stover yield of soybean over the weedy check.

The economic viability of different treatment combinations

The cost of production varied due to different weed managements strategies (Table 2). The cost of production varied mainly for hand weeding and herbicide treatment. In case of no weeding (control), there was no involvement of cost for weed management. In this experiment, the highest total cost of production (81348 Tk.) was in weed-free treatment and the lowest in no weeding or control treatment. Different weed management treatments influenced the gross return. The highest gross return (188160 Tk.) was in weed-free treatment, while the minimum (52380 Tk.) was in no weeding (control) treatment. The highest net return (106812 Tk.) was recorded in weed-free treatment, while the minimum (4630 Tk.) net return was in no weeding (control) treatment. The highest benefit-cost ratio (2.85) was obtained under post-emergence herbicide (Irish @ 1200 ml ha^{-1}) treatment, following that (2.78), pre-emergence herbicide (Herbilin 33% EC @ 400 ml ha^{-1}) while the lowest benefit-cost ratio (1.09) was obtained in no weeding (control) treatment. Although the weed-free treatment gave the highest return, the BCR analysis shows a comparatively lower BCR than many other treatments.

Table 2. Gross return, cost of production, net return, and benefit-cost ratio (BCR) of soybean under different weed management

Treatment	Gross return (*Tk ha^{-1})	Total cost of production (*Tk ha^{-1})	Net return (*Tk ha^{-1})	BCR
T_1	52380	47750	4630	1.10
T_2	130620	65550	65070	1.99
T_3	139130	49975	89155	2.78
T_4	146040	51310	94730	2.85
T_5	105650	53535	52115	1.97
T_6	127690	58875	68815	2.17
T_7	96650	60210	36440	1.61
T_8	164930	62435	102495	2.64
T_9	104400	52712	51688	1.98
T_{10}	80590	52200	28390	1.54
T_{11}	118360	54425	63935	2.17
T_{12}	188160	81348	106812	2.31

*1 US$ = 110 Bangladeshi Taka

Soybean seed = 1 kg 100 Taka ~1 ton = 100000 Taka; Stover value= 1 kg 1 Taka ~ 1 ton = 1000 Taka

Here, T_1: No weeding (Control), T_2: Two hand weeding (15 and 30 DAS), T_3: Pre-emergence herbicide (Herbilin 33% EC @ 400 ml ha^{-1}), T_4: Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_5: Pre (Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}), T_6: Pre-emergence(Herbilin 33% EC @ 400 ml ha^{-1}) + 1 hand weeding (40 DAS), T_7: Post-emergence(Irish @ 1200 ml ha^{-1}) + 1 hand weeding (40 DAS, T_8: Pre(Herbilin 33% EC @ 400 ml ha^{-1}) + Post-emergence herbicide (Irish @ 1200 ml ha^{-1}) + 1 hand weeding(40 DAS), T_9: Straw mulching, T_{10}: Intercrop with red amaranth, T_{11}: Intercrop with maize and T_{12}: Weed-free.

CONCLUSION

Different weed management strategies have significant effect on soybean crop yield and yield-contributing characteristics. Although weed-free treatments gave the highest yield parameters and yield, total gross return, and net return, the application of post-emergence herbicide Irish Sodium Acifluorfen 16.5% + Clodinafop Propargyl 8% EC @ 1200 ml ha^{-1} was the most economically viable treatment as it gave the highest benefit-cost ratio in soybean cultivation, which also influence the growth and increase its ability to enhance better yield production.

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