Effect of Integrated Weed Management Practices on Yield, Yield Attributes and Economics of Buckwheat (*Fagopyrum Esculentum* Moench) under Rainfed Conditions in Terai Region of West Bengal, India

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Abstract

A field experiment was carried out at Instructional Farm of UBKV, Pundibari, Coochbehar, West Bengal, India during the *rabi* seasons of 2009-10 and 2010-2011 to study the effect of integrated weed management practices on yield, yield attributes and economics of lesser known pseudo-cereal, buckwheat. Among the herbicidal treatments, pre-emergence (PE) application of Fluchloralin @ 2.22 l ha^{-1} + one hand weeding (HW) at 35 DAS and PE application of Fluchloralin @ 2.22 l ha^{-1} + post-emergence (PoE) application of Glyphosate @ 2.50 l ha^{-1}, PE application of Fluchloralin @ 2.22 l ha^{-1} and PoE application of Glyphosate @ 2.5 ha^{-1} each when applied alone, performed better in reducing weed density, dry weight of weeds through out the growing period resulted in higher yield attributing characters and ultimately higher weed control efficiency over control. Two hand weeding (HW) at 20 and 35 days after sowing (DAS) resulted in maximum reduction in weed density and dry weight and recorded the highest yield attributes, seed yield and benefit:cost ratio which was at par with PE application of fluchloralin integrated with one HW at 35 DAS, PE application of fluchloralin combine with PoE application of Glyphosate and hoeing twice at 20 and 35 DAS.

1. Introduction

Buckwheat is a multipurpose crop, belonging to genus *Fagopyrum* of the family Polygonaceae. The whole plant, young shoots, leaves, flowers and grains are used in a variety of ways. The tender shoots are used as leafy vegetable. The seed is used in several culinary preparations during fast and religious festivals. Its starchy flour mixed with wheat, rice or maize flour is used to prepare biscuits, noodles, pancakes and for gluten free diets. Husked kernels are cooked as rice, country liquors called pechuwi and chhang are made from buckwheat (Joshi and Paroda, 1991). Dried and green buckwheat plants, leaves and flowers are a good source of a glucoside named *rutin* which is used as a medicine in the treatment of several diseases. The biological value of protein is superior to other food plants and is nearly equal to that of eggs. The flowers of buckwheat are rich source of dark coloured and strong flavoured honey (Joshi and Rana, 1995).

Cropping season in this region is limited as the vast area (60-75%) remains fallow from November-February. Buckwheat is the only crop which can be taken successfully as a second crop after harvest of rice in the second fortnight of October to early part of November. This crop is getting momentum both in acreage and production because of short duration crop and it fits well in the double cropping system under this zone (Sah, 2012). The renewed interest in buckwheat is based on its nutritional composition and feasibility for cultivation but buckwheat is susceptible to severe weed competition, especially at the early growth stage. Thus, herbicides application is an important component in the cultivation of this crop but due to the lack of knowledge about its chemical control, its cultivation is still restricted.

Weeds pose a major threat to the productivity of buckwheat in this regions. The major weeds include *Digitaria sanguianalis* and *Equisetum arvenese.* To manage this problem, judicious use of the herbicides could be an alternative to manual weeding, which is tedious and cumbersome. The problem of weed is more vigorous in northern part of West Bengal, particularly in the sub-himalayan region. Areas having highest rainfall in the country, favours the growth of various types of weeds including some species of *Polygonum,* which was the weed of low lands earlier but now has shown the trends of invading winter crops fields also. This leads to the need for developing integrated weed management (IWM) practices for buckwheat

a neglected winter crop. Herbicide is an important tool in IWM as it reduces labour requirements and offers effective control on weeds, particularly during critical period of weed-crop competition. Herbicides have an overwhelming success in weed management when it is applied in proper doses. However, faulty use of herbicides with respect to dose and methods of application has a disastrous effect as it can also become lethal to crop plants.

Keeping this in view, the present investigation was carried out to study the performance of integrated weed management practices on Buckwheat.

2. Materials and Methods

A field experiment was carried out at Instructional Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Coochbehar, West Bengal, India during the *rabi* seasons of 2009-10 and 2010-2011. The soil of the experiment plot was sandy loam in texture having pH 5.8, organic carbon 1.06%, total nitrogen 0.12%,15.6 kg available P and 101.2 kg available K ha^{-1}. The experiment was laid out in Randomized Block Design (RBD) with seven treatments with three replications. The treatments consisted of pre-emergence application of Fluchloralin @ 2.22 a.i. kg ha^{-1} (T_1), post-emergence application of Glyphosate @ 2.50 a.i. kg ha^{-1} at 20 days after sowing (DAS) (T_2), Pre-emergence application of Fluchloralin @ 2.22 a.i. kg ha^{-1} + hand weeding (once) at 35 DAS (T_3), wheel-hoeing (twice) at 20 and 35 DAS (T_4), hand weeding(twice) at 20 and 35 DAS (T_5), pre-emergence application of Fluchloralin @ a.i. kg ha^{-1} combine with post-emergence application of Glyphosate @ 2.50 a.i. kg ha^{-1} at 20 DAS (T_6) and unweeded control (T_7). Sowing of Buckwheat variety VL-7 at the rate of 40 kg ha^{-1} was done in rows of 30 cm apart on 15th and 17th November, 2010 and harvested at 10th and 12th February, 2011, respectively. The crop was fertilized with 60 kg N, 30 kg P_2O_5 and 30 kg K_2O ha^{-1} in the form of urea, single super phosphate and muriate of potash, respectively. Half dose of N (30 kg ha^{-1}) and full dose of P and K (each 30 kg ha^{-1}) were applied as basal and remaining half dose of N (30 kg ha^{-1}) was top dressed at 25 days after sowing. Flat fan nozzle was used for herbicidal application, using a spray volume of 500 l ha^{-1}. Weed counts and weed dry weight were recorded with the help of quadrate (0.25 m^2) at two random spots in each plot at harvesting stage of crop. Weed control efficiency (WCE) was also calculated on the basis of dry weight of weeds.

3. Results and Discussion

3.1. Weed flora

The major weeds observed in the experimental plots were *Cynodon dactylon, Setaria glauca, and paspalum* sp. among grassy weeds; *Polygonum persicaria, P. pensylvanicum* and *P.orientale* and *Stellaria media, Chenopodium album, Ageratum conyzoides, Euphorbia hirta, Amaranthus* sp. and *Vicia sativa* among broadleaved weeds and *Cyperus* sp. among sedges were predominant. Among these weeds, *Cynodon dactylon* and *Polygonum* appeared in the field with high invasion, however, it became predominant during flowering and cyme development.

3.2. Effect on weeds

The data in Table 1 revealed that none of the herbicide treatments alone gave satisfactory weed control so far as weed population $unit^{-1}$ area was concerned. Combination of fluchloralin @ 2.22 a.i. kg ha^{-1} followed by hand weeding at 35 DAS (T_3) gave efficient weed control and recorded almost similar efficiency to that of hand weeding twice (T_5) during both the years of investigation. Hoeing twice at 20 and 35 DAS appreciably reduced the total weed population m^{-2} than unweeded control plot (T_7) during both the years of investigation. Among the herbicidal treatments, lowest number of grassy weeds was recorded when pre-emergence application of fluchloralin combined with one hand weeding at 35 DAS (T_3) was done followed by combined application of pre and post emergence herbicide (T_6). Grassy weeds population was quite less under hoeing twice (T_4) than pre-emergence application of fluchloralin during both years of experimentation (Table 1). It was observed from the Table 1 that the crop had low infestation of sedge weeds during both the years of experimentation. Among the treatments tried in this investigation, pre-emergence application of fluchloralin @ 2.22 l ha^{-1} followed by one hand weeding at 35 DAS (T_3) was found to be the most effective in reducing sedge weeds population $unit^{-1}$ area and was significantly superior to pre-emergence application of fluchloralin (T_1,) and post-emergence application of glypsosate (T_2) when applied alone. Hand Hoeing twice at 20 and 35 DAS (T_4) also recorded lower sedge weeds population over control (T_7). The highest sedge weeds population was recorded under unweeded control (T_7). Among the herbicidal treatments, pre-emergence application of fluchloralin along with one hand weeding at 35 DAS (T_3) gave the best control of broad leaved weeds during both the years of experimentation. Hoeing twice at 20 and 35 DAS (T_4) recorded lower broad leaved weeds over the application of the herbicides when applied alone (T_1 and T_2) during both the years of investigation. It would be seen from the Table 1 that hand weeding twice at 20 and 35 DAS (T_5) gave effective control of grassy and sedges weeds $unit^{-1}$ area as measured by dry weight of grassy and sedges weeds m^{-2} during both the years of investigation. Pre-emergence application or fluchloralin followed by one hand weeding at 35 DAS (T_3) gave excellent controlled of grassy and sedge weeds as measured by dry weight of grassy and sedge weeds $unit^{-1}$ area. This was due to low grassy and sedges weed populations in these treatments

Table 1: Effect of treatments on different categories of weeds population and dry weight at harvest

Treatments	Grasses				Sedges				Broad leaves				Total			
	Y_1		Y_2		Y_1		Y_2		Y_1		Y_2		Y_1		Y_2	
	P	W	P	W	P	W	P	W	P	W	P	W	P	W	P	W
T_1	10.5	11.1	11.1	10.4	6.3	11.5	5.2	10.7	70.4	19.3	66.1	18.1	87.2	41.9	82.4	39.2
T_2	9.8	10.6	9.7	9.5	5.6	10.4	4.5	9.3	63.5	16.2	60.2	16.8	78.9	37.2	74.4	35.6
T_3	7.1	7.5	6.8	6.9	5.2	7.2	4.3	6.8	44.6	12.2	40.7	12.4	56.8	26.9	51.7	26.1
T_4	9.3	8.6	8.6	8.2	6.5	10.3	4.9	9.1	52.7	15.9	52.6	15.1	68.5	34.8	66.5	32.3
T_5	6.8	7.9	7.4	7.1	3.6	7.5	3.1	6.7	28.8	4.8	25.3	4.9	39.2	20.2	35.8	18.7
T_6	8.9	9.4	9.1	7.3	5.7	9.1	5.3	7.8	52.2	11.3	49.1	12.2	66.8	29.8	63.4	27.5
T_7	15.8	19.5	14.1	17.3	8.9	17.4	7.6	16.5	117.9	42.4	116.6	42.9	142.6	79.3	138.3	76.7
CD*	2.69	1.29	2.51	1.37	1.50	0.81	1.45	0.19	2.98	1.79	2.45	1.87	9.1	2.17	8.3	2.34

Y_1=2009-2010; Y_2=2010-2011; *(p=0.05); P: Weed population (no. m^{-2}); W: Weed drymatter (g m^{-2})

(Table 1) and lesser dry matter accumulation by grassy and sedge weeds. This was closely followed by pre-emergence application of fluchloralin combined with post emergence application of glyphosate (T_6).

Irrespective of the years of experimentation, the dry weight of broad leaved weeds $unit^{-1}$ area increased with the age of weeds till the last observation recorded at harvest. Hand weeding twice at 20 and 35 DAS (T_5) effectively controlled broad leaved weeds growth as measured by dry weight of broad leaved weeds $unit^{-1}$ area during both the years of experimentation (Table 1). Pre-emergence applications of fluchloralin @ 2.22 lt ha^{-1} followed by one hand weeding at 35 DAS (T_3) gave the best control of weeds as measured by dry weight of weeds $unit^{-1}$ area during both the years of experimentation. This was closely followed by pre-emergence application of fluchloralin combined with post-emergence application of glyphosate (T_6). The data on weed control efficiency have been shown in Table 4. Highest weed control efficiency was recorded under hand weeding twice (T_5) followed by pre-emergence application of herbicide along with one hand weeding at 35 DAS (T_3), pre + post-emergence application of herbicide (T_6) and hoeing twice (T_4) Lowest value of weed control efficiency was recorded when pre-emergence application of fluchloralin (T_1) was applied.

3.3. Effect on crops

Perusal of data in Table 2 would revealed that plant height under unweeded control plot recorded shortest plant height irrespective of the years of the investigation. Highest plant height was recorded when hand weeding was done twice at 20 and 35 DAS (T_5) followed by pre-emergence application of fluchloralin @ 2.22 lt ha' integrated with one hand weeding at 35 DAS (T_3) during both the years of investigation. The data pertaining to the effect of treatments on plant height, yield attributes of buckwheat (the number of cymes $plant^{-1}$, number of seeds $cyme^{-1}$, and test weight), seed yield and weed control efficiency of buckwheat have been presented in Table 2. Observations recorded during both the years of investigation revealed that number of cymes $plant^{-1}$ in general recorded

Table 2: Effect of treatments on plant height, yield attributes, seed yield and weed control efficiency

Treatments	Plant height (cm)		No. of Cymes $plant^{-1}$		No. of seeds $cyme^{-1}$		Test wt. (g)		Seed Yield (q ha^{-1})		Weed Control efficiency	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	67.3	70.9	24.1	25.2	3.4	3.9	28.4	29.1	13.68	14.46	47.2	48.9
T_2	68.9	72.1	25.4	26.1	3.6	4.2	30.6	30.7	15.05	16.21	53.0	53.5
T_3	75.1	77.5	27.7	28.9	4.8	5.1	32.1	32.3	20.68	21.69	66.1	65.9
T_4	70.7	73.8	26.1	26.7	4.2	4.4	31.4	31.6	17.23	18.28	56.1	57.8
T_5	77.3	79.8	28.7	30.6	5.2	5.7	32.5	33.8	22.92	24.96	74.5	75.6
T_6	81.9	75.4	26.1	27.2	4.6	4.9	31.5	31.9	18.78	19.35	62.4	64.2
T_7	52.6	54.4	16.1	17.6	3.1	3.3	23.9	24.5	9.81	10.98	-	-
CD (p=0.05)	1.96	1.62	1.12	1.05	0.41	0.45	0.95	0.78	1.03	1.12	-	-

Y_1=2009-2010, Y_2=2010-2011

higher value during the second year of trial compared to the first year. Number of cymes plant^{-1} was lowest in unwedded control plot during both the years of investigation. This was due to stiff weed-crop competition in unwedded control plot which adversely affected vegetative vigour of the plant and was reflected on the number of cymes plant^{-1}. Highest number of cymes plant^{-1} was recorded under hand weeding twice (T_5) followed by pre-emergence application of fluchloralin along with one hand weeding at 35 DAS (T_3), pre and post-emergence application of herbicides (T_6) and hoeing twice at 20 and 35 DAS (T_4) during both the years of investigation. Number of seeds cymes^{-1} recorded the lowest value in unwedded control plot (T_7) during both the years of investigation. Highest number of seeds cyme^{-1} was recorded under hand weeding twice at 20 and 35 DAS (T_5) followed by pre-emergence application of fluchloralin combined with one hand weeding at 35 DAS (T_3), pre and post-emergence application of herbicides (T_6) and hoeing twice at 20 and 35 DAS (T_4) during both the years of investigation.

Hand weeding twice (T_5) significantly recorded the highest test weight during both the years of investigation. Unweeded control plot (T_7) showed the poorest performance with regard to test weight due to severe crop-weed competition from early stage of crop growth to maturity of the crop which adversely affect vegetative as well as reproductive vigour of plant and these was reflected on the test weight of seeds. The highest seed yield was recorded under hand weeding (twice) (T_5) in both the years of investigation, these was closely followed by pre-emergence application of fluchloralin combined with hand weeding at 35 DAS (T_3) and pre-emergence application of fluchloralin along with post-emergence application of glyphosate at 20 DAS (T_6).

3.4. Economics

Different weed control practices influenced the gross income (Table 3) the highest gross income was recorded under hand weeding twice (T_5) followed by pre-emergence application of fluchloralin along with one hand weeding (T_3) and pre-emergence and post emergence application of fluchloralin and glyphosate

Table 3: Effect of treatments on economics

Treatments	Cost of Treatments (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Gross Income (₹ ha^{-1})		Net Income (₹ ha^{-1})		Benefit Cost ratio	
			Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	1335	13,835	27,360	28,920	13,525	15,085	0.97	1.09
T_2	1025	13,525	30,100	32,420	16,575	18,895	1.22	1.39
T_3	3023	15,523	41,360	43,380	25,837	27,857	1.66	1.79
T_4	1688	14,188	34,460	36.560	20,272	22,372	1.42	1.57
T_5	4500	17,000	45,840	49,680	28,840	32,680	1.70	1.92
T_6	2360	14,860	37,560	38,700	22,700	23,840	1.52	1.60
T_7	12500	12500	19,620	21,960	7,120	9,460	0.57	0.75

Cost of cultivation (₹ ha^{-1}) =12500; Y_1 =2009-2010, Y_2 =2010-2011; Labour charge: ₹112.50 man^{-1}; Unit price of seed: ₹ 2000 q^{-1}

respectively (T_6). Lowest gross income was recorded under un weeded control plot (T_7).

Net income was also influenced by different weed control practices. Maximum net income was recorded under hand weeding twice (T_5) and this could be attributed to highest seed yield in buckwheat. The minimum net income was recorded unweeded control plot (T_7) due to lowest seed yield of buckwheat. Benefit: cost ratio was highest under hand weeding twice (T_5) because of higher net return which was followed by T_3, T_6 and T_4. Under T_4, (Hoeing twice) treatment the benefit:cost ratio was higher than the T_2 and T_1 treatments. This is due to the low cost of treatment occurred during hoeing operation.

4. Conclusion

It may be concluded that the hand weeding twice at 20 and 35 DAS (T_5) recorded highest yield attributing characters, seed yield, net income and benefit-cost ratio over other weed control practices which is environmentally sound, socially acceptable and economically viable.

5. References

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