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PHYSIO-MORPHOLOGICAL APPRAISAL OF BUCK WHEAT (*FAGOPYRUM ESCULENTUM* M.) AS INFLUENCE BY INTEGRATED WEED MANAGEMENT PRACTICES

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ABSTRACT

This study was carried out to investigate the effect of integrated weed management practices on buckwheat (*Fagopyrum esculentum* M). Among the varying weed management practices two hands weeding at 20 and 35 days after sowing (DAS) recorded the higher plant height, number of cymes plant^{-1}, dry matter accumulation (DMA), leaf area index (LAI), crop growth rate (CGR) and Net assimilation rate (NAR) due to the maximum reduction in weed density and dry weight. The highest yield attributes and yield was recorded in two hands weeding at 20 and 35 days after sowing (DAS) followed by pre-emergence application of fluchloralin @ 2.22 lt.ha^{-1} and post-emergence application of glyphosate @ 2.50 lt. ha^{-1} at 20 days after sowing (DAS) produces higher yield over unweeded control whereas pre-emergence application of fluchloralin @ 2.22 lt. ha^{-1} followed by one hand weeding at 35 DAS produces seed yield comparable to hand weeding (twice) treatment. It may be concluded that two hands weeding at 20 and 35 DAS is best for obtaining overall gain in cultivation of buckwheat.

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INTRODUCTION

Buckwheat (*Fagopyrum esculentum* Moench) is an annual crop of pseudo cereal group that belongs to the Polygonaceae family. It is cultivated in India, Germany, Austria and other countries (Bernath, 2000). This traditional crops known as pseudo-cereal have been grown for generation on marginal soil under low input managements by the backwards and tribal people for their food and nutrition. The potential of this crop need urgent attention for improvement as it hold enormous potential for exploitation and can be used for enlarging the food basket for humankind (Joshi and Sharma, 2000).

Effective weed management is critical to maintaining agricultural productivity (Ahmed *et al.*, 2010; Verma, 2014) as it can lead to billions of dollars in global crop losses annually (Das and Yaduraja, 2008; Srinivasrao *et al.*, 2014). It reduces crop yield and quality. Weed management is the shifting of the crop-weed balance so that yield is not economically reduced (Altieri and Letarneau, 1982) which is considered on the basis of its economic, ecological and a sociological consequence as it is not only depends on technical solutions but relies also on other criteria (Shaw, 1982).

Higher seeding rates to smother weeds (Hore and Rathi, 2002; Chernetskii, 1975), one or two hand weeding to tackle the weed menace and manual weeding not only takes a major share of the farm labour but is tedious and uneconomical. Herbicides are effective to control initial flush of weeds which usually remain out of reach of the other methods of weed control and also have been found quite effective in buckwheat (Rana *et al.*, 2003a). However, herbicidal weed control is not aimed at replacing any other non-chemical option available to the farmer. Rather, herbicides should be looked upon as supplement to cultural, physical and other methods of weed control to obtain superior and more efficient and economical control of weeds than is possible with the existing methods alone.

The main difficulty of buckwheat cultivation is due to weed competition (Sakalien*et al.* 2000) as it is the major production constraint impairing buckwheat productivity (Rana *et al.*, 2003). Therefore, there must have a long range strategy to predict and avoid potential weed problems in the future. Considering these mentioned reasons a study on integrated weed management practices on growth and yield of buckwheat a neglected winter pseudo-cereal crop was carried out under *Terai* region of West Bengal.

MATERIALS AND METHODS

The experiment was conducted at the Farm of Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar, West Bengal during 2011-2012 and 2012-2013. The experimental field was laid out in Randomized Block Design, having seven (7) treatments with three (3) replications. The treatments consisted of pre-emergence application of fluchloralin @ 2.22 lt. ha^{-1}(T_1), post-emergence of application of glyphosate @ 2.50 lt. ha^{-1} (T_2), pre-emergence application of fluchloralin @ 2.22 lt. ha^{-1} + hand weeding (once at 35 DAS) (T_3), hoeing (Twice) 20 and 35 DAS (T_4), hand weeding (twice) at 20 and 35 DAS (T_5), pre-emergence application of fluchloralin @ 2.22 lt. ha^{-1}combined with post-emergence application of glyphosate @ 2.50 lt. ha^{-1} (T_6) and Unweeded control (T_7). The results were analyzed taking consideration of pre harvest parameters like plant height, number of cymes $plant^{-1}$, dry matter accumulation (DMA), Leaf area index (LAI), according to the formula given by Watson, 1952.

$$\text{Leaf area index (LAI)} = \frac{\text{Area of total number of leaves surface}}{\text{Ground area from which leaf sample were collected}}$$

Then the mean LAI (L) was calculated as per the formula given below.

$$\text{Mean LAI (L)} = \frac{L_2 - L_1}{Log_e L_2 - Log_e L_1}$$

Where, L_1 and L_2 are the leaf area indices at two successive occasions on time t_1 and $t_2$respectively.

Crop Growth Rate [(CGR) (gm m^{-2} day^{-1})] it is calculated according to the formulagiven by Watson, 1952.

$$CGR = \frac{W_2 - W_1}{t_2 - t_1}$$

Where, $W_1$and $W_2$was the dry weight of the aerial plants per unit area gained at time $t_1$and t_2 respectively.

Net assimilation rate. Briggs *et al.* (1920) preferred the term unit leaf rate to net assimilation rate. Net assimilation rate was worked out by the following formula given by Watson (1958) and is expressed as gram of day matter produced per square meter of leaf area per day (g m^{-2} day^{-1}).

$$NAR = \frac{(W_2 - W_1) \, Log_e L_2 - Log_e L_1}{(t_2 - t_1) \, (L_2 - L_1)} = \frac{CGR}{\text{Mean LAI (L)}}$$

Where, L_1 and W_1 are the leaf area and dry weight of plants at time t_1. L_2 and W_2 are the leaf area and dry weight of plants at time T_2. The post harvest parameters like number of cymes $plant^{-1}$, number of seeds $cyme^{-1}$, test weight (g), seed yield, stem yield and harvest index (%).

RESULTS AND DISCUSSION

Effect of treatments on plant height and number of cymes per plant

Plant height went on increasing till the last observation recorded at harvest due to indeterminate type of growth habit. In general, unweeded control plot recorded the shortest plant height at any particular stage of crop growth irrespective of the year of the investigation (Table 1). This was probably due to presence of larger number of weed population per unit area compared to any other treatment causing greater weed-crop competition and there by affecting the growth of plant as measured by plant height.Hoeing and herbicide treatments did not record any depressive effect on plant height. However, Brajkishor *et al.* (2015) reported that one hand weeding, hoeing and integrated with pre-emergence application of herbicides significantly influenced the growth of crop. The 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^{-1} and integrated with one hand weeding at 35 DAS (T_3). This might be due to the reduced competition of nutrient, space, moisture, light and effectively suppression of weeds which ultimately enhanced the plant height.

The 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 & 35 DAS (T_4) at all the stages of crop growth. It might be due to the effective weeds control throughout the growth of the crop and less weed-crop competition in these treatments which encourage vegetative vigour and ultimately increased number of cymes $plant^{-1}$(Table 2). Similar observation also reported by Rana *et al.* (2003).

Effect of treatments on LAI, DMA, CGR and NAR

Leaf area index (LAI) was low at the early stage of crop growth and kept on increasing with the advancement of crop age up to 60 DAS when it reached its peak. There after it declined towards maturity of the crop touching the lowest value at harvest. This was due to the emergence and enlargement of new branches and leaves during vegetative stage of the crop growth, which stopped at the reproductive stage of the crop growth. Another reason may be attributed to senescence of leaves at the later stages of the crop growth. Among the weed control practices the highest LAI was recorded under hand weeding twice at 20 and 35 DAS (T_5) at all the stages of crop growth (Table 3). The lowest LAI was recorded under control might be due to weed-crop competition for nutrients, space, moisture and light. Dry matter accumulation (DMA) was the lowest at 30 DAS there after rapid accumulation of dry matter was noticed till harvest. The rate of accumulation became slower and it reached maximum value at the last observation at harvest (Table 4). The rate of DMA increased at an increasing rate up to 75 DAS and there after it increased with decreasing rate, irrespective of weed control treatments. This indicates that the initial growth rate measured by the DMA was slow at vegetative stage of crop growth which peaked up as the crop passed through the flowering, seed filling and maturity stage. Among the weed control practices the highest dry matter accumulation 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 + post emergence application of fluchloralin @ 2.22 lt. ha^{-1} + glyphosate @ 2.50 lt. ha^{-1} (T_6) and hoeing twice at 20 and 35 DAS (T_4) (Table 4). Among the weed control practices the highest values of crop growth rate (CGR) was recorded under hand weeding twice at 20 and 35 DAS (T_5) followed by pre-emergence application of fluchloralin @ 2.22 lt. ha^{-1} along with one hand weeding at 35 DAS (T_3), pre + post-emergence application of fluchloralin + glyphosate respectively (T_6), hoeing twice at 20 &35 DAS (T_4). Lowest values of CGR were recorded under unweeded control (T_7) (Table 5).

Physiological growth functions like net assimilation rate (NAR) at different stages of crop growth revealed that irrespective of different weed control practices, NAR kept on increasing successively in successive observations till the period of 45-

Table 1: Effect of treatments on plant height of buckwheat

Treatments	Plant height Days after sowing (DAS) 30		45		60		75		At harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	13.48	13.88	20.06	20.67	30.48	31.78	48.73	50.9	62.5	63.75
T_2	14.74	15.04	20.32	21.97	32.91	33.09	51.87	53.09	62.44	65.37
T_3	17.03	17.5	22.97	23.26	35.43	37.04	56.57	58.12	66.3	68.53
T_4	16.19	16.58	20.72	21.44	33.11	34.57	54.28	55.39	65.81	65.92
T_5	18.53	18.66	23.61	24.76	40.2	41.38	60.51	62.11	71.07	73.97
T_6	16.11	16.95	20.18	22.81	36.18	38.48	56.17	57.93	62.79	67.5
T_7	10.73	11.63	14.5	15.67	24.94	26.98	40.63	42.99	43.72	48.81
S.E m (±)	0.39	0.56	0.56	0.6	0.89	0.65	1.06	0.64	0.96	0.64
C. D. (P =0.05)	1.21	1.74	1.73	1.84	2.73	1.99	3.27	1.96	2.97	1.97

Y_1 = 2011-2012 and Y_2 = 2012-2013

Table 2: Effect of treatments on number of cymes per plant of buckwheat

Treatments	Number of cymes per plant Days after sowing (DAS) 30		45		60		75		At harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	1	1	9.78	10.21	21.03	21.2	25.31	26.15	31.88	32.15
T_2	1	1	11.43	11.7	23	23.36	26.03	27.37	32.09	32.37
T_3	1.66	1.67	13.24	13.24	24.14	25.77	28	28.98	34.66	35.96
T_4	1.33	1.33	12.03	12.08	22.73	23.77	28.96	29.4	33.34	33.4
T_5	2.33	2.66	13.92	15	26.31	27.85	33.2	34.38	37.2	42.38
T_6	1.33	1.33	12.4	12.98	23.18	24.33	30.39	32.11	34.39	35.11
T_7	0.67	0.8	9.29	8.19	12.66	16.74	22.55	23.19	21.55	23.19
S.E m (±)	0.29	0.26	0.34	0.26	0.55	0.7	1.77	0.6	1.77	0.6
C. D. (P =0.05)	0.88	0.8	1.05	0.81	1.71	2.05	5.45	1.85	5.45	1.85

Y_1 = 2011-2012 and Y_2 = 2012-2013

Table 3: Effect of treatments on Leaf Area Index (LAI) of buckwheat

Treatments	Leaf area index Days after sowing (DAS) 30		45		60		75		At harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	0.11	0.15	1.5	1.66	2.29	2.34	1.31	1.46	1.18	1.29
T_2	0.14	0.18	1.62	1.74	2.34	2.46	1.53	1.66	1.21	1.4
T_3	0.18	0.27	2.06	2.1	2.94	3.25	1.99	2.16	1.6	1.71
T_4	0.16	0.2	1.69	1.81	2.51	2.66	1.67	1.82	1.34	1.46
T_5	0.21	0.39	2.13	2.31	3.29	3.58	2.09	2.27	1.73	1.84
T_6	0.17	0.23	1.89	1.97	2.7	2.89	1.81	2.02	1.48	1.6
T_7	0.06	0.09	1.01	1.07	1.79	1.86	0.98	1.14	0.34	0.66
S.E m (±)	0.02	0.01	0.06	0.01	0.02	0.03	0.01	0.005	0.02	0.02
C. D. (P =0.05)	0.05	0.03	0.17	0.03	0.05	0.08	0.04	0.014	0.05	0.07

Y_1 = 2011-2012 and Y_2 = 2012-2013

Table 4: Effect of treatments on Dry Matter Accumulation (DMA)

Treatments	Dry matter accumulation (g m^{-2}) Days after sowing (DAS) 30		45		60		75		At harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	52.7	56.2	75.1	81.2	164.7	171.1	217.8	225.1	238.1	248.7
T_2	55.1	59.5	79.8	86.5	170.2	179.1	226.9	236.3	250.6	261.5
T_3	65.3	68.9	96.8	104.5	196.9	206.7	265.8	275.8	298.5	310.7
T_4	58.7	63.3	85.2	93.9	179.8	190.8	239.9	252.7	267.7	281.6
T_5	69.1	74.5	106.5	112.9	210.7	218.7	283.2	291.4	317.8	329.3
T_6	62.7	66.1	92.1	98.6	190.1	198.3	253.4	263.6	283.9	294.3
T_7	35.9	39.3	56.6	61.9	144.3	153.7	192.5	200.8	210.7	220.9
S.E m (±)	2.41	0.21	1.19	1.06	1.01	1.56	1.75	1.68	1.29	0.83
C. D. (P =0.05)	7.44	0.65	3.65	3.27	3.11	4.82	5.38	5.18	3.97	2.54

Y_1 = 2011-2012 and Y_2 = 2012-2013

Table 5: Effect of treatments on crop growth rate (CGR)

Treatments	Crop growth rate (g m^{-2} day^{-1}) Days after sowing (DAS)							
	30-45		45-60		60-75		75-Harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	1.62	1.67	5.83	6.13	3.53	3.59	1.35	1.57
T_2	1.64	1.8	6.02	6.17	3.77	3.81	1.57	1.68
T_3	2.09	2.37	6.66	6.8	4.59	4.6	2.17	2.32
T_4	1.77	2.03	6.3	6.45	4.33	4.12	1.85	1.92
T_5	2.49	2.56	6.95	7.04	4.83	4.86	2.3	2.53
T_6	1.95	2.16	6.53	6.64	4.22	4.35	2.03	2.18
T_7	1.37	1.5	3.81	3.93	2.22	2.43	1.32	1.38
S.E m (±)	0.1	0.07	0.11	0.16	0.2	0.09	0.13	0.14
C. D. (P =0.05)	0.32	0.22	0.34	0.49	0.61	0.28	0.4	0.43

Y_1 = 2010-2011 and Y_2 = 2011-2012

Table 6: Effect of treatments on net assimilation rate (NAR)

Treatments	Net assimilation rate (g m^{-2} day^{-1}) Days after sowing (DAS)							
	30-45		45-60		60-75		75-Harvest	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	1.45	1.52	3.83	4.33	1.55	2.52	0.47	0.8
T_2	1.48	1.55	4.05	4.58	1.58	2.55	0.55	0.89
T_3	1.54	1.6	4.37	4.9	1.64	2.82	0.64	0.98
T_4	1.5	1.56	4.13	4.7	1.6	2.67	0.58	0.92
T_5	1.6	1.67	4.48	5.15	1.7	2.93	0.72	1.05
T_6	1.52	1.58	4.24	4.84	1.62	2.71	0.6	0.93
T_7	1.2	1.27	3.51	4.11	1.3	1.93	0.33	0.66
S.E m (±)	0.01	0.01	0.01	0.11	0.03	0.04	0.007	0.02
C. D. (P =0.05)	0.04	0.04	0.03	0.33	0.09	0.13	0.022	0.06

Y_1 = 2010-2011 and Y_2 = 2011-2012

60 DAS when it reached at its maximum and thereafter it declined successively in successive observation recorded till 60-75 DAS (Table 6). The reproductive phase of the crop roughly coincided with 45-60 DAS and it was natural that NAR was at its maximum in this phase, when there was fullest manifestation of all the vegetative parts of the plants along with flower initiation. At the later stage when crop was in ripening phase and had no further vegetative growth, it showed a declining trend in NAR. At this stage, seed filling took place partly by transport and partitioning from storage in vegetative parts and partly synthesis with limited plant parts other than leaves i.e. stem and green clusters (cyme) of buckwheat.The NAR which indicated the photosynthetic efficiency of the leaf was influenced significantly by different weed control practices. NAR decreased with crop maturity (Table 6). The significantly highest NAR value was recorded under hand weeding twice (T_5) and lowest NAR value was recorded under control treatment (T_7).

Effect of treatments on yield attributes of buckwheat at Harvest

The 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 i.e. fluchloralin @ 2.22 lt. ha^{-1} and glyphosate @2.50 lt. ha^{-1} respectively (T_6) and hoeing twice at 20 and 35 DAS (T_4) (Table 7). This might be due to the light of lesser weed- crop competition in these treatments which encouraged vegetative vigour and ultimately increase the number of cymes per plant. Number of seeds per cyme recorded the lowest value in unweeded control plot (T_7) and highest number of seeds per cyme was recorded under hand weeding twice at 20 & 35 DAS (T_5). Similar results also confirmed by Chhetri and Mahato (2015). 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) also significantly influenced the yield attributes (Table 7). This might be due to the lesser weed- crop competition throughout the period of crop growth resulted in fullest manifestations of all the plant parts during each of the development phases of the plant and produced more number of cymes per plant and more number of seeds per cyme.The seed yields of common buckwheat were positively correlated with straw yield and other yield attributing characters like number of cymes per plant, numbers of seeds per plant, plant density and plant height, but negatively correlated with weed biomass Rana *et al.* (2003). The lowest test weight was recorded under unweeded control (T_7). This might be due to the severe crop- weed competition from early stage of crop growth to maturity of the crop which adversely affect vegetative growth as well as reproductive vigour of plant and these was reflected on the test weight of seeds. The highest test weight was recorded under hand weeding twice (T_5) at 20 and 35 DAS.

Effect of treatments on grain yields, stick yield and harvest index of buckwheat

The highest seed yield was recorded under hand weeding

Table 7: Effect of treatments of yield attributes of buckwheat

Treatment	No. of cymes plant^{-1}		No. of seeds cyme^{-1}		Test weight (g)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	31.88	32.15	7.67	7.99	19.29	19.53
T_2	32.09	32.38	8	8.33	20.05	20.32
T_3	34.66	35.96	10.6	10.66	22.64	22.91
T_4	33.34	33.66	8.33	8.67	20.77	20.97
T_5	37.2	42.38	11.33	12	23.65	23.81
T_6	34.39	35.11	9.67	10.33	21.44	21.85
T_7	23.55	25.19	7	7.33	17.04	17.08
S.E m (±)	1.77	0.6	0.42	0.44	0.34	0.29
C. D. (P = 0.05)	5.45	1.85	1.31	1.36	1.04	0.88

Y_1 = 2011-2012 and Y_2 = 2012-2013

Table 8: Effect of treatments on seed yield, stem yield and harvest Index

Treatment	Seed yield (q ha^{-1})		Stem yield (q ha^{-1})		Harvest index (%)	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
T_1	6.27	7.12	13	14.23	32.93	33.35
T_2	7.16	7.98	14.53	15.42	33.01	34.1
T_3	8.85	9.42	15.65	16.25	35.82	35.81
T_4	7.8	8.08	14.88	16.15	34.04	34.88
T_5	9.62	10.49	16	17.06	38.6	39.13
T_6	8.39	8.97	15.05	16.05	34.9	35.22
T_7	5	5.25	12.79	13	28.1	28.76
S.E m (±)	0.1	0.11	0.37	0.16	0.14	0.28
C. D. (P = 0.05)	0.31	0.34	1.13	0.5	0.44	0.87

Y_1 = 2011-2012 and Y_2 = 2012-2013

(twice) (T_5) (Table 8) 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). This might be due to the reduced the competition of light, water, space and nutrients which ultimately increased the crop growth and yield. This result also conformity withVerma, 2014. Post-emergence application of glyphosate when applied at 20 DAS (T_2) produced high seed yield than pre-emergence application of fluchloralin (T_1). However, Rana *et al.* (2004) reported that once hand weeding and integrated with herbicides significantly influenced the yield. Hoeing twice at 20 and 35 DAS (T_4) recorded higher seed yield than the herbicidal treatment when applied alone (T_1 and T_2). The pre-emergence application of herbicides like Chloridazon increased grain yield by 10.5-12.5% such an increase was significantly compared with the control (Kavoliunaite, 2003). The lowest seed yield was recorded under unweeded control (T_7) during both the years of experimentation (Table 8).The stem yield was significantly influenced by the different weed control practices. The maximum stem yield was obtained under hand weeding twice (T_5) followed by pre-emergence application of fluchloralin along with one hand weeding (T_3), pre-emergence and post-emergence application of fluchloralin and glyphosate respectively (T_6). Pre-emergence application of fluchloralin (T_1) and post-emergence application of glyphosate when applied alone gave higher stem yield over unweeded control. Singh *et al.*, (2014) reported that the herbicides like Imazethapyr at 20 DAS has been found to effectively reduced weed density and weed biomass of associated weeds which ultimately enhanced the seed and stem yield. The lowest value of stem yield was recorded under unweeded control (T_7). The table 8 depicts that harvest index varied significantly due to different weed control practices. The highest value of (38.60 and 39.13%) harvest index was noted when hand weeding was done at 20 & 35 DAS (T_5) followed by pre-emergence application of fluchloralin @ 2.22 lt. ha^{-1} along with one hand weeding at 35 DAS (T_3), pre + post-emergence application of fluchloralin + glyphosate respectively (T_6) and hoeing twice at 20 & 35 DAS (T_4). Pre-emergence application of fluchloralin (T_1) and post-emergence application of glyphosate (T_2) significantly recorded highest harvest index over control. The lowest harvest index was recorded under (28.10 and 28.76 %) unweeded control.

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