



Efficacy of chemical and non-chemical methods of weed management in rainfed potato (*Solanum tuberosum*)

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ABSTRACT

A field experiment was conducted during two consecutive summer season of 2011 and 2012 at Central Potato Research Station, Shillong to evaluate comparative efficacy of chemical and non-chemical methods of weed management in rainfed potato (*Solanum tuberosum* L.) cultivation of Meghalaya. Maximum reduction in crop yield due to presence of weed by 34.4% and 37.2% during first year and second year, respectively was found under weedy check plot followed by farmers' practices compared to weed free treatment. Application of metribuzin @ 1.0 kg ai/ha as pre emergence caused the highest reduction in total weed density and weed dry matter accumulation as compared to other herbicides during the both the years. However, the maximum weed control efficiency was observed under weed free treatment followed by application of metribuzin. The mean data of two year revealed that the maximum potato tuber yield (28.2 tonnes/ha) were recorded in the weed free followed by application of metribuzin @ 1 kg ai / ha. However, the net return and B:C ratio were significantly higher with the application of metribuzin @ 1 kg ai /ha.

Key words: Herbicide, Potato, Tuber yield, Weed control efficiency, Weed index

In Meghalaya potato (*Solanum tuberosum* L.) is widely cultivated under rainfed conditions. However, the per unit potato production is abysmally low (10.9 tonnes/ha) and there exists a yield gap to the extent of 52% compared to the national average 22.7 tonnes/ha (Anonymous 2010). There are several constraints associated in potato production, viz. acidic soils, mostly rainfed condition, high incidence of disease and pest, quality of seed, improper plant nutrition and high infestation of weed. Because of heavy rains during crop season, weeds pose a serious problem in potato crop in this region. In potato, heavy infestation of weeds during initial growth severely affects the nutrient and light availability leading to gradually decline in yield. Potato though possesses robust growing and quick spreading habit; it is a very poor competitor with weeds because of its extremely slow growth in the initial emergence phase (Channappagoudar *et al.* 2007). Weeds not only compete with crop plants for nutrients, soil moisture, space and sunlight but also serve as an alternative hosts for several insect pests and diseases. The tuber yield reduction due to weeds in potato is estimated to be as high as 10 to 80 per cent (Lal and Gupta 1984). So, control of weeds in the initial stages appears imperative as it plays an important role in maximizing the tuber production. Manual weeding is

traditional practice and quite effective but it is expensive, tedious, time consuming and also causes root injury (Khurana *et al.* 1993). However, timely weed control may not be possible manually due to non-availability of labours accompanied by their high rate of wages and also their poor working efficiency used to induce by incessant rains and consequent wet condition during peak period of farm operations. Proper weed management strategy needs to be developed to reduce its adverse impact on yield thereby increasing the potato productivity in the region. In such conditions chemical control is the only method for checking the early weed growth, reduces mechanical damage to the plants and to check the spread of mechanically transmitted viruses. Keeping this in view, an experiment was carried out to evaluate the comparative efficacy of chemical and non-chemical methods of weed management in rainfed potato.

MATERIALS AND METHODS

A field experiment was conducted during two consecutive summer season of 2011 and 2012 at Central Potato Research Station, Shillong. The geographical coordinates of experimental field are 25°54' N latitude and 91°84' E longitude and an altitude of 1 738 m above mean sea level. The soil was sandy loam in the texture with pH 5.12, moderately fertile, being high in organic carbon (1.88%), and medium in available nitrogen (305.5 kg/ha), low in available phosphorus (14.5 kg/ha) and high in available potassium (298.0 kg/ha). Soil pH was determined in 1: 2 soil: water suspension (Jackson 1973), organic

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carbon by wet acid oxidation of organic matter (Walkley and Black 1947). Available N, P and K were determined by Alkaline potassium permanganate methods (Subbiah and Asija 1956), Bray and Kurtz methods (1945) and neutral ammonium acetate methods (Jackson 1971), respectively. The trial were laid out in randomized block design, replicated thrice, with 12 treatments, viz. weedy check (No measure to adopted to control the weed from planting to harvesting the crop), weed free check (maintaining zero population of weed throughout the crop season by manual weeding), one hand weeding with earthing up, farmers' practices, mulching with organic material, metribuzin @ 1.0 kg ai/ha, oxyfluorfen @ 0.2 kg ai /ha, pendimethalin @ 1.0 kg ai /ha, metribuzin @ 1.0 kg ai/ha followed by one hand weeding at 40 DAP, oxyfluorfen @ 0.2 kg ai /ha followed by one hand weeding at 40 DAP, pendimethalin @ 1.0 kg ai/ha followed by one hand weeding at 40 DAP and two hand weedings at 20 and 40 DAP. All the herbicides were applied as a pre emergence in the experiment. Mean standard monthly meteorological data (Fig 1) were taken from meteorological observatory, Shillong. During both the crop seasons a mean rainfall of 624 mm was received from February to June. Maximum temperature varied between 20 and 25°C during crop seasons. Similarly, minimum temperature varied between 8 and 18°C. In farmers' practice one hand weeding at earthing up was done. In weed free check weeding was done weekly as and when the weeds emerged in the field by manual labour. The crop was planted during the first week of March and harvested in the month of June. The recommended dose of fertilizer for this region @ 150: 120: 60 kg N, P₂O₅ and K₂O/ha, respectively. Half dose of nitrogen and full dose of P and K were applied at the time of planting, whereas remaining N was given at earthing up stages. Kufri Jyoti was taken as the potato variety for this experiment. The other recommended package of practices was followed as per recommendation of crop in the region like two spray of Mancozeb and one spray of Curzate (Cymoxanil 8% + Mancozeb 64%) were used for controlling late blight of potato. The crop was harvested at around 110 days after

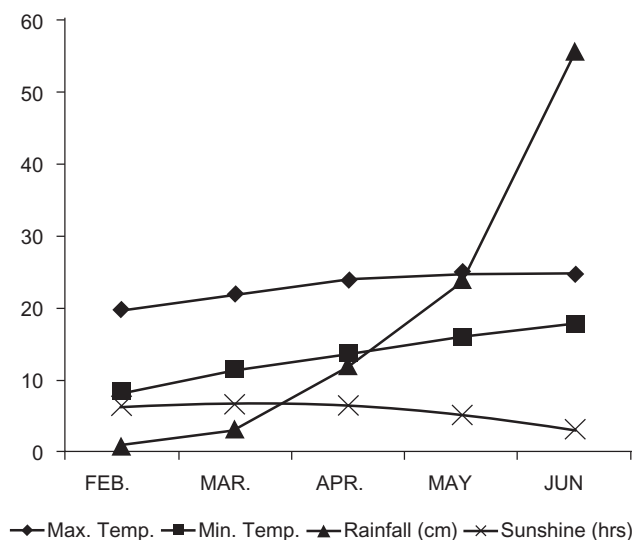


Fig 1 Mean monthly standard metrological data of crop season.

planting in the last week of June. The observations on weed count and weed dry weight were taken after 90 days of planting. The weed counts were subjected to square root transformation ($\sqrt{x+0.5}$) to normalize the distribution. Weed control efficiency and weed index were also worked out to assess the efficiency of different weed-control treatments. At maturity, tubers were harvested from net plot area (3.6m × 3.6m) and yield was expressed on tonne (t) per hectare basis. The herbicides were applied by using knapsack sprayer fitted with flat fan nozzle and a directing hood using 800 litres of water/ha as pre-emergence. Density and dry weight of weeds/m² were taken using quadrants in each plot and then removing the weeds from base. Weeds dry matter was determined after drying at 80°C for 48 hours maintaining constant moisture content. The data were subjected to statistical analysis. The weed control efficiency (WCE) and weed index of each treatment were calculated using the following formula based on weed dry matter.

$$\text{Weed control efficiency (\%)} = \frac{(\text{WDC}-\text{WDT})}{\text{WDC}} \times 100$$

where, WDC is the weed dry matter (g/m²) in control plot (weedy check); WDT is the weed dry matter (g/m²) in treated plot; in both WDC and WDT; the unit should be same or uniform.

$$\text{Weed index (\%)} = \frac{(\text{Yield in weed free plot} - \text{Yield in treated plot})}{\text{Yield in weed free plot}} \times 100$$

The economics were computed using the prevailing market prices for inputs and outputs (cost of output such as potato tuber used @ ₹ 10 000/tonne). All observations for each character were subjected to statistical analysis according to the standard method. The calculated values of the treatments and error variance ratio were compared with Fisher and Yates F table at 5 per cent level of significance. The differences between significant treatments means were tested against CD at 5 per cent probability.

RESULTS AND DISCUSSION

Major weed flora

Following major weed flora were observed in experimental field, viz. *Plantago major*, *Hydrocotyle javanica*, *Eupatorium odoratum*, *Gynura crepidioides*, *Cassia mimosoides*, *Senecio densiflorus*, *Oxalis corniculata*, *Oxalis griffithii*, *Polygonum alatum*, *Potentilla kleiniana*, *Solanum khasiana*, as broad leaved weeds while *Cyperus cyperoides*, *Imperata cylindrica*, *Arundinella nepalensis*, *Arundinella khasiana*, *Cyperus* sp., *Spergula arvensis*, *Zephyranthes pumilus*, *Commellina diffusa*, *Arthraxon* sp., *Brachiaria reptans*, *Capillipedium assimile*, *Digitaria adscendens*, *Paspalum orbiculare*, are narrow leaves weeds found in potato field. Similar weeds in potato field were also reported by Yadav *et al.* (2014).

Weed density and weed dry matter

All the weed control treatments significantly reduced the weed density and dry weight during both the year of

Table 1 Effect of different treatment on density of narrow leaved, broad leaved and total density

Treatment	Narrow leaved weeds (no/m ²)		Broad leaved weed (no/m ²)		Total weed density (no/m ²)	
	2011	2012	2011	2012	2011	2012
Weedy check	18.2 (332.9)	17.9 (320.6)	21.3 (451.4)	20.9 (434.8)	28.0 (784.4)	27.5 (755.4)
Weed free	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)
HW 40 DAP + earthing up	13.5 (182.7)	13.1 (171.7)	14.0 (194.7)	13.7 (186.7)	19.4 (377.3)	18.9 (358.3)
Farmers' practice	15.3 (235.3)	14.9 (220.7)	15.8 (247.7)	15.4 (238.0)	22.0 (482.9)	21.4 (458.7)
Organic mulching	13.4 (179.1)	12.8 (163.2)	13.9 (192.3)	13.4 (180.0)	19.3 (371.4)	18.5 (343.2)
Metribuzin 1.0 kg ai/ha	9.4 (88.7)	8.8 (77.0)	7.9 (62.3)	7.4 (54.3)	12.3 (151.0)	11.5 (131.3)
Oxyfluorfen 0.1 kg ai/ha	9.9 (96.7)	9.3 (85.3)	8.2 (66.7)	7.7 (59.0)	12.8 (163.3)	12.0 (144.3)
Pendimethalin 1.0 kg ai/ha	10.0 (99.3)	9.6 (92.3)	8.5 (71.0)	8.0 (64.3)	13.1 (170.3)	12.5 (156.7)
Metribuzin 1.0 kg ai/ha+HW	8.0 (64.2)	7.8 (60.8)	6.0 (35.7)	5.7 (32.3)	10.0 (99.8)	9.7 (93.2)
Oxyfluorfen 0.1 kg ai/ha+HW	8.6 (73.3)	7.9 (62.7)	6.3 (39.7)	6.0 (36.0)	10.6 (113.0)	10.0 (98.7)
Pendimethalin 1.0 kg ai/ha+HW	8.9 (78.7)	8.7 (75.0)	6.6 (43.4)	6.3 (39.0)	11.1 (122.0)	10.7 (114.0)
Two HW at 20 and 40DAP	11.8 (139.7)	11.4 (130.7)	12.7 (160.7)	12.1 (146.1)	17.3 (300.4)	16.6 (276.8)
SE±	0.48	0.29	0.36	0.42	0.32	0.33
CD(P=0.05)	0.99	0.60	0.74	0.86	0.66	0.69

Data subjected to square root ($\sqrt{x+0.5}$) transformation and figures in parentheses are original values

experiments as compared to weedy check (Table 1). Among the herbicides, metribuzin application either in combination with hand weeding or without hand weeding was very effective in controlling all kinds of weeds in potato. Hence, weed density was significantly less in this treatment when compared with other weed management practices except weed free treatment. Similar findings have been reported earlier also by Yadav *et al.* (1999). Weed density under other herbicides treatments with hand weeding practices were at par and these were significantly lower than that of weedy check. The data presented in Table 1 shown that weedy check treatment recorded the highest weed density as well as weed biomass during both the year of investigation (Suresh and Reddy 2010).

Weed biomass in general has direct relationship with

weed densities. Hence, the lowest weed dry weight was recorded under weed free treatment followed by other weed management practices and the highest under weedy check (Kumar *et al.* 2010). The weed density of broad leaved weeds were higher than the narrow leaved weeds but dry weight were noticed to be almost equal to each other because of moisture content of broad leaved weeds were higher as a result of lower dry weight per unit area as compared to the narrow leaved weed.

Weed control index and weed control efficiency

Weed index is the reduction in crop yield due to presence of weeds in comparison with weed-free check, which is an ideal parameter to judge the effectiveness of herbicide. The weed index among different treatments was found to be in

Table 2 Effect of weed management practices on dry weight of narrow leaved, broad leaved and total biomass of weeds

Treatment	Dry matter of narrow leaved weeds (g/m ²)		Dry matter of broad leaved weeds (g/m ²)		Dry matter weed biomass(g/m ²)	
	2011	2012	2011	2012	2011	2012
Weedy check	10.6 (113.0)	10.3 (106.1)	9.9 (98.7)	9.7 (93.4)	14.6 (211.7)	14.1 (199.5)
Weed free	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)	0.7 (0.0)
HW 40 DAP + earthing up	6.9 (47.5)	6.5 (42.0)	6.7 (44.7)	6.3 (39.8)	9.6 (92.2)	9.1 (81.8)
Farmer's practice	9.4 (88.4)	8.9 (78.9)	8.7 (75.0)	8.5 (72.3)	12.8 (163.4)	12.3 (151.2)
Organic mulching	6.7 (44.7)	6.4 (41.0)	6.5 (41.3)	6.3 (39.3)	9.3 (86.0)	9.0 (80.3)
Metribuzin 1.0 kg ai/ha	5.9 (34.7)	5.8 (33.0)	6.0 (35.7)	5.8 (33.0)	8.4 (70.3)	8.2 (66.0)
Oxyfluorfen 0.1 kg ai/ha	6.2 (38.6)	6.2 (37.8)	6.4 (40.5)	6.1 (37.2)	8.9 (79.1)	8.7 (75.0)
Pendimethalin 1.0 kg ai/ha	6.5 (42.2)	6.3 (39.7)	6.7 (43.8)	6.4 (39.9)	9.3 (86.0)	8.9 (79.7)
Metribuzin 1.0 kg ai/ha+HW	5.0 (24.4)	4.6 (20.7)	4.8 (22.9)	4.6 (20.3)	6.9 (47.3)	6.4 (40.9)
Oxyfluorfen 0.1 kg ai/ha+HW	5.2 (27.1)	4.7 (22.0)	5.0 (24.5)	4.8 (22.5)	7.2 (51.6)	6.7 (44.5)
Pendimethalin 1.0 kg ai/ha+HW	5.5 (29.7)	5.1 (25.6)	5.4 (28.3)	5.1 (25.0)	7.6 (58.0)	7.1 (50.6)
Two HW at 20 and 40DAP	6.4 (40.7)	6.1 (36.7)	6.2 (38.3)	6.1 (37.0)	8.9 (79.0)	8.6 (73.7)
SE±	0.3	0.3	0.4	0.2	0.4	0.3
CD(P=0.05)	0.7	0.5	0.8	0.4	0.9	0.6

Data subjected to square root ($\sqrt{x+0.5}$) transformation and figures in parentheses are original values

Table 3 Effect of weed management practices on weed control efficiency, weed index, potato tuber yield and economics ($\times 10^3$ ₹/ha)

Treatment	Weed control efficiency (%)		Weed index (%)		Potato tuber yield (tonnes/ha)			Cost of cultivation mean	Net return		B:C ratio	
	2011	2012	2011	2012	2011	2012	Mean		2011	2012	2011	2012
Weedy check	0.0	0	34.4	37.2	19.1	17.2	18.1	78.3	112.7	93.7	1.4	1.2
Weed free	100.0	100.0	0.0	0.0	29.1	27.4	28.2	104.6	186.4	169.4	1.8	1.6
HW 40 DAP + earthing up	56.5	59.0	21.0	25.2	23.0	20.5	21.8	90.6	139.4	114.4	1.5	1.3
Farmers' practice	22.8	24.2	30.9	30.7	20.1	19.0	19.6	85.3	115.7	104.7	1.4	1.2
Organic mulching	59.4	59.7	24.4	20.4	22.0	21.8	21.9	84.5	135.5	133.5	1.6	1.6
Metribuzin 1.0 kg ai/ha	66.8	66.9	4.5	5.8	27.8	25.8	26.8	81.4	196.6	176.6	2.4	2.2
Oxyfluorfen 0.1 kg ai/ha	62.6	62.4	7.6	12.8	26.9	23.9	25.4	80.7	188.3	158.3	2.3	2.0
Pendimethalin 1.0 kg ai/ha	59.3	60.1	10.7	8.8	26.0	25.0	25.5	80.4	179.6	169.6	2.2	2.1
Metribuzin 1.0 kg ai /ha +HW	77.7	79.5	3.8	5.5	28.0	25.9	26.9	88.4	191.6	170.6	2.2	1.9
Oxyfluorfen 0.1 kg ai/ha+ HW	75.6	77.7	5.5	6.9	27.5	25.5	26.5	87.7	187.3	167.3	2.1	1.9
Pendimethalin 1.0 kgai/ha +HW	72.6	74.6	7.2	10.6	27.0	24.5	25.8	87.4	182.6	157.6	2.1	1.8
Two HW at 20 and 40DAP	62.7	63.1	15.8	16.1	24.5	23.0	23.7	92.3	152.7	137.7	1.7	1.5
SE±					1.1	1.2	1.2					
CD(P=0.05)					2.3	2.6	2.4					

the range of 3.8–37.2% (Table 3). The maximum reduction in crop yield due to presence of weed by 34.4 and 37.2% during first year and second year, respectively was found under weedy check plot followed by farmers' practices compared to weed free treatment (Prakash *et al.* 2006). Application of herbicide either alone or in combination with manual hand weeding was found to be more effective to control the weeds in the potato crop. Hence, the reduction in the crop yield due to application of herbicides (metribuzin +one hand weeding) were recorded the lowest values except to weed free plot during the both the year of investigation.

Weed dry matter is a better parameter to measure the competition than the weed number. Weed management practices noticed higher weed control efficiency over weedy check. The range of weed control efficiency among different weed management practices varied between 22.8 and 100%. The maximum weed control efficiency was observed under weed free treatment followed by application of metribuzin in combination with one hand weeding after 40 days of planting. This may be due to lower dry weight of weeds. The weed infestations were observed to be the highest in weedy check followed by the farmers' practices, as a result of highest dry weight of weeds were recorded which reduced the weed control efficiency.

Yield and economics of potato

The economic yield of potato tuber was noticed to be the highest (28.2 tonnes/ha) in the weed free plot followed by metribuzin application in combination with hand weeding. This result is also with conformity of Jaiswal (1994). The second highest productivity of potato were noticed under herbicides treatment that being at par with other weed management practices which were significantly higher over weedy check during the both the year of investigation. The data revealed that all weed management practices being at par with each other showed the significant improved in potato productivity over weedy check (Table

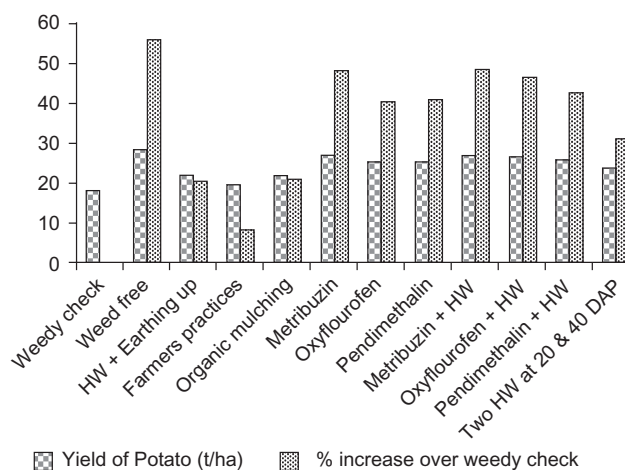


Fig 2 Enhancement of potato yield through weed management practices over weedy check.

3). This was due to that the herbicides application, facilitate to remove as weeds in both inter and intra row spacing where mulching and farmers practices from inter row only, which resulted in lower crop weed competition under herbicides treatment. Hence, higher yield was obtained under herbicides application in comparison to mulching and farmers' practices. The yield enhancement through weed management practices over weedy check treatment has been illustrated in Fig 2. Maximum improvement in productivity of potato was noticed by 55.7% under weed free treatment over the weedy check (Yadav and Kumar 2011). The higher yields under weed management practices were mainly due to the better growth and development of crops under low crop weed competition and greater availability of soil nutrients and light as well as better utilization of other resources to crop plants.

The economics of the experiments was given in the Table 3 shown that the reduction in cost of cultivation was recorded under improved weed management practices. The

overall reduction in cost of cultivation of potato were noticed the highest in metribuzin application followed by oxyfluorfen and pendimethalin which were at par to each other and significantly superior over weed free check. Weed free check and farmers practices required more labour for weeding when compared with herbicides application. Therefore, cost of cultivation was higher in weed free check and farmer practices as well as hand weeding treatment either one or two times. Lower cost of cultivation and higher yield in herbicides treatment (except weed free check where maximum cost of cultivation while minimum cost of cultivation in weedy check with the lowest yield) resulted in more net returns than farmers practices.

Thus it may be concluded that application of metribuzin @ 1 kg ai/ha as a pre emergence is enough for maximum net returns and benefit cost ratio from potato cultivation in rainfed condition of Meghalaya.

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