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Weed management practices in potato [*Solanum tuberosum* L.]

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Potato is one of the most important commercial vegetable crops widely grown in India. Growth and development of potato and its tuber yield depends on biogenetic potential of a variety and cultural practices to which crop is subjected. There are several constraints in potato production, of which weeds often pose a serious problem. Even though potato plants have robust growing and quick spreading nature but it turns as a weak competitor with weeds. Weeds not only compete with crop plants for nutrients, soil moisture, space and sunlight but also serve as an alternative hosts for several insect pest and diseases. Wider spacing, frequent irrigations and liberal use of manures and fertilizers provide favorable conditions for an early start of weeds well before the emergence of potato plant. Singh and Bhan (1999) reported that the presence of weeds through out the growing season caused 62% reduction in tuber yield. It was observed that the most critical period of crop-weed competition is first 4-6 weeks after planting when the crop must be kept free from weeds. The 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. Timely weed control may not be possible manually due to non-availability of labours. Hence, chemical weed control in integrated weed management appears to hold a great promise in dealing with effective, timely and economic weed control. Farmers in this region usually grow potato without having proper knowledge on use of herbicide. Keeping all these points in view the investigation was planned to generate information on weed flora and to find out suitable and economically viable weed management practices for potato.

The field experiments were conducted during *rabi* seasons of 2006 and 2007 at research farm of Uttar Banga Krishi Viswavidyalaya and also through participatory mode at Khagribari, Cooch Behar, West Bengal to find out effective and economical weed management practices in potato. The soil was sandy to sandy loam in texture (Sand 63%, silt 21%, clay 16%), medium in fertility with pH 5.57, organic carbon 0.58% and available N, P and K at research farm were 162.3, 17.6 and 85.2 kg ha^{-1}. Ten weed management practices *viz.*, metribuzin @ 0.30 kg ha^{-1} at 7 days after planting (DAP) as early post-emergence in ridge planted potato followed by earthing up at 45 DAP, metribuzin @ 0.50 kg ha^{-1} at 7 DAP in ridge planted potato followed by earthing up at 45 DAP, pendimethalin @ 0.60 kg ha^{-1} as pre-emergence in ridge planted potato followed by earthing up at 45 DAP, oxyflourfen @ 0.10 kg ha^{-1} as pre-emergence in ridge planted potato followed by earthing up at 45 DAP, isoproturon @ 0.50 kg ha^{-1} as pre-emergence in ridge planted potato followed by earthing up at 45 DAP, paraquat @ 0.50 kg ha^{-1} as early post-emergence at 2-3% emergence of potato plant (10 DAP) in ridge planted potato followed by earthing up at 45 DAP, mulching with rice straw @ 10 t ha^{-1} after planting of potato in ridges, farmer's practice (flat bed planting with 2-hand weeding at 15 DAP and 30 DAP and earthing up at 45 DAP), weedy check and weedy-free check were replicated thrice in randomized block design both at research farm and farmer's field. The potato cv. 'Kufri Jyoti' @ 2,000 kg seed tuber ha^{-1} with the average weight of 30 gm was planted in the plot of 6 x 5 m in size. The fertilizer dose of 150 kg N + 30.6 kg P + 100 kg K ha^{-1} was applied both at research farm and farmer's field. Nitrogen and potassium were applied in two splits *i.e.* $^1/_2$ as basal and $^1/_2$ at earthing up operation and entire phosphorus was applied at basal. Weed count was made using quadrate having the size of 0.25 X 0.25 m from four randomly selected points of individual plot and total dry weight of the weeds was measured. Data on weed dry weight was analyzed after subjecting to square-root transformation (X + 1). Economics was calculated on the basis of prevailing market price of inputs used and output obtained from each treatment. Sale price of potato ₹4300 $tonne^{-1}$ (2006) and ₹ 4800 t^{-1} (2007); input price: potato seed, ₹9 kg^{-1} (2006) and ₹12 kg^{-1} (2007), rice residue, ₹0.80 kg^{-1}, Urea, ₹ 4.78 kg^{-1}, SSP, ₹3.22 kg^{-1}, MOP, ₹4.45 kg^{-1}; herbicides (litre kg^{-1}): metribuzin, ₹ 1900, pendimethalin, ₹444, oxyflourfen, ₹1890, isoproturon, ₹364, paraquat, ₹285, labour wage, ₹75.10 man day^{-1}, man days required for mulching, 15 ha^{-1}, man days required for each hand weeding, 30 ha^{-1}, man days required for spraying of herbicide, 5 ha^{-1}, man days required for earthing up, 30 ha^{-1}.

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Table 1: Effect of treatments on tuber yield, weed dry weight, weed control efficiency (WCE), net return, benefit cost ratio and weed index

Treatments	Tuber yield (t ha^{-1})		Weed dry weight (g m^{-2}) at harvest		WCE (%)at harvest		Net return (x 10^3 ₹ ha^{-1})		Benefit: Cost ratio		Weed index (%)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Metribuzin 0.3 kg ha^{-1} at 7 DAP	18.38	22.49	7.6 (57.6)	7.3 (52.4)	76.54	77.05	37.109	65.43	0.89	1.54	3.62	2.64
Metribuzin 0.5 kg ha^{-1} at 7 DAP	9.51	10.98	6.1 (36.2)	5.7 (31.7)	85.23	86.14	-1.573	9.65	-0.04	0.22	50.13	52.47
Pendimethalin 0.6 kg ha^{-1} as pre-emergence	17.57	21.51	8.3 (67.6)	7.7 (59.1)	72.45	74.15	33.553	60.66	0.80	1.42	7.87	6.88
Oxyflourfen 0.1 kg ha^{-1} as pre-emergence	16.78	19.93	8.9 (78.2)	8.6 (72.4)	68.14	68.32	30.239	53.16	0.72	1.25	12.01	13.72
Isoproturon 0.5 kg ha^{-1} as pre-emergence	16.53	18.95	9.2 (82.8)	9.1 (81.7)	66.25	64.25	29.726	49.02	0.72	1.17	13.32	17.97
Paraquat 0.5 kg ha^{-1} at 10 DAP	16.60	18.37	9.6 (92.2)	9.6 (91.0)	62.42	60.16	29.677	45.88	0.71	1.08	12.95	20.48
Mulching with rice straw (10 t ha^{-1})	18.60	22.82	7.4 (53.3)	7.2 (51.5)	78.26	77.48	32.372	61.34	0.68	1.27	2.46	1.21
Farmer's practice (HW at 15 and 30 DAP)	16.65	18.56	9.4 (87.9)	9.2 (84.3)	64.14	63.12	26.355	43.26	0.58	0.94	12.69	19.65
Complete weed free condition	19.07	23.10	1.0 (0.0)	1.0 (0.0)	100.00	100.00	-	-	-	-	0.00	0.00
Complete weedy condition	9.66	11.27	15.6 (245.3)	15.1 (228.5)	0.00	0.00	0.804	12.77	0.02	0.31	49.34	51.21
SEm (±)	**0.51**	**0.63**	**0.51**	**0.37**								
LSD(0.05)	**1.10**	**1.30**	**1.10**	**0.78**								

Table 2: Effect of treatments on tuber yield, weed dry weight, weed control efficiency (WCE), net return, benefit cost ratio and weed index at farmer's field

Treatments	Tuber yield (t ha^{-1})		Weed dry weight (g m^{-2}) at harvest		WCE (%) at harvest		Net return (x 10^3 ₹ ha^{-1})		Benefit: Cost ratio		Weed index (%)	
	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007	2006	2007
Metribuzin 0.3 kg ha^{-1} at 7 DAP	22.47	25.67	6.8 (45.4)	6.7(44.0)	78.24	77.82	54.70	80.70	1.30	1.90	2.73	1.50
Metribuzin 0.5 kg ha^{-1} at 7 DAP	11.38	12.73	5.4 (28.6)	5.1 (24.8)	86.29	87.51	6.47	18.05	0.15	0.42	50.74	51.15
Pendimethalin 0.6 kg ha^{-1} as pre-emergence	22.15	25.44	7.5 (55.5)	7.2 (50.3)	73.41	74.62	53.25	79.53	1.27	1.87	4.11	2.38
Oxyflourfen 0.1 kg ha^{-1} as pre-emergence	19.73	21.77	8.5 (72.1)	8.3 (67.1)	65.43	66.18	42.92	61.99	1.02	1.46	14.59	16.46
Isoproturon 0.5 kg ha^{-1} as pre-emergence	19.58	20.93	8.6 (72.6)	8.4 (69.9)	65.16	64.75	42.84	58.52	1.04	1.40	15.24	19.69
Paraquat 0.5 kg ha^{-1} at 10 DAP	18.24	20.46	8.8 (76.6)	8.7 (74.5)	63.27	62.45	36.73	55.92	0.88	1.32	21.04	21.49
Mulching with rice straw (10 t ha^{-1})	22.70	25.78	6.6 (43.1)	6.4 (39.4)	79.32	80.16	50.00	75.55	1.05	1.57	1.73	1.07
Farmer's practice (HW at 15 and 30 DAP)	20.38	22.56	8.3 (67.9)	8.0 (63.2)	67.46	68.14	42.39	62.46	0.94	1.36	11.77	13.43
Complete weed free condition	23.10	26.06	1.0 (0.0)	1.0 (0.0)	100.00	100.00	-	-	-	-	0.00	0.00
Complete weedy condition	12.37	13.43	14.5 (208.5)	14.1 (198.4)	0.00	0.00	12.46	23.14	0.31	0.56	46.45	48.47
SEm (±)	**0.92**	**1.00**	**0.25**	**0.19**								
LSD(0.05)	**1.90**	**2.10**	**0.53**	**0.40**								

Note: HW=hand weeding, DAP=days after planting, Data transformed to (X + 1) figures in parentheses indicate original values.

The weed flora of potato field at research farm was comprised by *Polygonum persicarea* L., *Polygonum pensylvanicum* L., *Stellaria media* Cyrill., *Oldenlandia diffusa* L., *Chenopodium album* L. (broadleaved), *Cynodon dactylon* (L) Pers. (grass) and *Cyperus rotundus* L. (sedge). *Polygonum sp.*, *Cynodon dactylon* (L) Pers. and *Cyperus rotundus* L. These weeds were highly aggressive at the initial stage of crop and continuously emerged through out crop season resulting in higher state of crop-weed competition even before emergence of crop. Among the weed management practices, metribuzin @ 0.50 kg ha^{-1} at 7 DAP recorded highest weed control efficiency both at research farm and at farmers' field during harvest. This treatment was closely followed by mulching, metribuzin @ 0.30 kg ha^{-1} and pendimethalin @ 0.60 kg ha^{-1}. However, higher dose of metribuzin recorded highest weed index values. Higher values of both weed control efficiency and weed index reflected the non-selective action of metribuzin at that dose. Among the weed management practices, mulching registered highest weed control efficiency and lowest weed index values closely followed by metribuzin @ 0.30 kg ha^{-1} and pendimethalin @ 0.60 kg ha^{-1}. Higher value of weed control efficiency and lower value of weed index of mulching, metribuzin @ 0.30 kg ha^{-1} and pendimethalin @ 0.60 kg ha^{-1} made them effective in controlling weeds without showing phytotoxicity on potato plant. Mulching, metribuzin @ 0.30 kg ha^{-1} and pendimethalin @ 0.60 kg ha^{-1} yielded at par to weed-free check. Mulching of rice straw immediately after planting of seed tuber in ridges considerably increased tuber yield up to 17.33% at research farm and 12.83% at farmers' field over farmers' practice. 2 to 3 days earlier emergence of potato plant was recorded in mulching treatment and this was because of maintaining soil temperature and conserving soil moisture leading to early emergence and establishment of potato plants. Similar finding is also reported by Lal (1990), Lal and Grewal (1991). Mulching also suppressed weed growth resulting in low weed-crop competition during emergence and vegetative growth stages of potato. Among the herbicidal treatments, metribuzin @ 0.30 kg ha^{-1} and pendimethalin @ 0.60 kg ha^{-1} caused stunted growth of potato plant for short period after emergence and crop recovered completely at later part of its growth stages. Both the herbicides at their respective doses became effective in controlling weeds leading to increased tuber yield of 15.78% (metribuzin) and 10.59% (pendimethalin) at research farm and; 12.02% (metribuzin) and 10.73% (pendimethalin) at farmers' field over farmers' practice. Metribuzin @ 0.50 kg ha^{-1} showed phytotoxicity on potato plant after emergence and crop remained stunted throughout crop growth resulting in poor tuberization and lowest tuber yield (Table 1 and 2). Incidence of late blight disease appeared at epidemic level in 2006 caused marked difference on tuber yield between 2006 and 2007. Weeds in complete weedy situation removed 35.65 to 40.47 kg N, 6.86 to 7.85 kg P and 49.81 to 50.04 kg K ha^{-1} from soil. Metribuzin @ 0.30 kg ha^{-1} applied at 7 DAP in ridge planted potato followed by earthing up at 45 DAP was found effective in controlling weeds and thus restricted removal of 36.03 to 31.93 kg N, 7.33 to 6.55 kg P and 45.15 to 44.40 kg K ha^{-1} from soil by the weeds. Metribuzin @ 0.30 kg ha^{-1} fetched highest net return of ₹51270 at research farm and, ₹67700 at farmers' field (Table 1 and 2). Even though mulching registered highest tuber yield among the weed control practices, however, cost of rice straw involved as input cost reduced monetary return and benefit cost ratio and the values were even lower than pendimethalin treatment.

It may be concluded that the application of metribuzin @0.30 kg ha^{-1} (early post-emergence) or pendimethalin @0.60 kg ha^{-1} (pre-emergence) treatment in ridge planted potato followed by earthing up at 45 DAP were effective for controlling weeds, getting higher production and profitability. Rice straw mulching significantly increased the tuber yield over the chemical control both at research farm and farmers' filed.

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