Journal of Crop and Weed, 15(3): 201-208 (2019) ISSN- O : 2349 9400 ; P : 0974 6315

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Bio-efficacy evaluation of oxyfluorfen 23.5% EC for controlling weeds in potato crop

U. BHATTACHARYA, S. SARKAR AND [1]S. DEWANJEE

Department of Agronomy, [1]Department of Genetics and Plant Breeding
Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia-741252, West Bengal.

Received : 18.11.2019 ; Revised : 15.12.2019 ; Accepted : 09.01.2020

DOI: 10.22271/09746315.2019.v15.i3.1260

ABSTRACT

Two years field study was carried out at D block research farm of B.C.K.V Kalyani, to evaluate the bio-efficacy of Oxyfluorfen 23.5% EC to control weeds in potato during the Rabi seasons of 2016 - 2018. The experiment was carried out in a Randomized Block Design with four replications i.e, T_1- Oxyfluorfen 23.5% EC @ 425 ml ha^{-1}, T_2- Oxyfluorfen 23.5% EC @ 625 ml ha^{-1}, T_3 - Oxyfluorfen 23.5% EC @ 850 ml ha^{-1}, T_4- Metribuzin 70% WP @ 0.75 kg ha^{-1}, T_5- straw mulch, T_6- Two hand weedings at 20 and 40 days after sowing (Weed free check) , T_7-Untreated control (weedy check). From the experiment, it is concluded that among different treatments, hand weeding at 20 and 40 days after crop sowing (T_6), maintained its superiority with highest control of weeds and crop yield (25.80 t ha^{-1}).All the herbicides had been applied as pre-emergence. Among herbicidal treatments, Oxyfluorfen 23.5% EC @ 850 ml ha^{-1} showed higher efficiency in controlling weeds with respect to number and dry weight of weeds after weed free check system. Based on the studies, the use of Oxyfluorfen 23.5% EC @ 850 ml ha^{-1} can be suggested for the control of weeds in potato crop.

Keywords: Bioefficacy, oxyflourfen, potato, weed biomass, yield

The fourth most important crop in the world after rice,wheat and maize is potato. In world second largest producer of potato is India after China. India produced about 48.52 million tones of potato (Government of India, 2018); 26 per cent of which was produced by West Bengal itself. Weed management in potato is quite challenging due to unavailability of laborers for hand weeding at peak period of crop weed competition and scarcity of suitable herbicide. Weeds interference in potato increases crop-weed competition and thereby reduces the number and size of tubers. Hence uncontrolled weed growth can reduce tuber yield from 18%-20 per cent. Oxyfluorfen is a contact herbicide having both pre-emergence and post-emergence activity (Ensminger *et al.*, 1985). In potato oxyfluorfen used as a pre-emergence herbicide is beneficial for controlling wide range of weeds. It will control weeds at early crop growth stage, thus reducing crop weed competition in its premium growth stage. Its indiscriminate use can cause toxic effect on potato and on its succeeding crop owing to its low water solubility (0.116mg/lit), vapor pressure (2x10^{-6}mm Hg) and high soil organic carbon sorption coefficient (K_{oc}) of 10,000ml g^{-1}. Therefore it may cause potential harm to the environment (Janaki *et al.*, 2013). In order to find out suitable doses of oxyfluorfen for efficient controlling of weeds without causing any toxic effect on soil physico-chemical and biological properties this experiment has been carried out.

MATERIALS AND METHODS

The experiment was carried out at D Block Farm, B.C.K.V., Kalyani which is in New Alluvial Zone (NAZ) of West Bengal. The experimental farm which was situated at 28^0 5.3$^{c}_{d}$N latitude and 83^0 5.3$^{c}_{d}$ E longitude with an elevation of of 9.75 m above the mean sea level. Topography of the land was referred as medium land situation. The trial was carried out to study the Bio-efficacy evaluation of Oxyfluorfen 23.5% EC for controlling weeds in Potato crop during the *Rabi* seasons of 2016-2018. The experiment was designed in Randomized Block Design having four replications (Table 1). Tuber cuttings treated with Indofil M-45, each weighing 40-50 gm having 3-4 eyes each of Kufri Jyoti variety were planted on 2nd December 2016 and 1st December 2017 at a spacing of 20 x 60 cm @ 25 q ha^{-1}. Recommended doses of fertilizers *i.e* 150:100:100 N, P_2O_5 , K_2O kg ha^{-1} was applied. Full doses of P_2O_5 and K_2O in the form of Single Super Phosphate and Muriate of Potash respectively; half doses of nitrogen in the form of urea were applied at basal dose. The rest half of N in the form of urea was given at the time of earthing up in two equal splits at 20 days after planting and 40 days after planting. All intercultural operations were followed accurately. Irrigations were given during earthing up. Herbicide was sprayed using a knapsack sprayer having a flat fan nozzle with a spray volume of 500 ml ha^{-1}. At 4 days after crop sowing spraying is done as pre emergence application on 6th December 2017. In weed free check plots, at 20 and 40 days after crop sowing two hand weedings were done. Potato was harvested on 16 th February 2016 and 14 th February 2017

Bioefficacy: Periodic observations at 15, 30, 45 and 60 days after crop sowing were done from randomly

Email : urjashibhattacharya@gmail.com

selected one sq m area per plot to study species wise weed population for the treatments (2-3). Number and dry weight of each weed species/m^2 was recorded. Observations on yield attributes, tuber and haulm yield per plot were also recorded at crop harvest and hectare based yield of the crop was calculated (Table 8). Weed control efficiency was also calculated (Table 4-7). The weed control efficiency (WCE) was calculated by using following formula. SPSS software has been used for statistical analysis of the data.

$$WCE\% = \frac{\text{Dry weed biomass in untreated control plot - Dry weed biomass in treated plot}}{\text{Dry biomass in untreated control plot}} x100$$

Table 1: Details of Treatments

Treatments	Product	Dosage (ml ha^{-1})	Dilution in water (Litre ha^{-1})
T_1	Oxyfluorfen 23.5% EC	425	500
T_2	Oxyfluorfen 23.5% EC	650	500
T_3	Oxyfluorfen 23.5% EC	850	500
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	500
T_5	Straw mulch	-	-
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	-	-
T_7	Untreated control (weedy check)	-	-

RESULTS AND DISCUSSION

Weed density

Results(Table 2 and 3) showed that in the experimental plots most prevalent weed species were Sedge*: Cyperus rotundus* and Broad leaves: *Chenopodium album, Melilotus alba, Phalaris minor etc*. Weed population increased with the increase in duration after crop sowing when there was no application of weed management practice. Untreated control (weedy check) (T_7) treatment registered highest weed population throughout the crop growth period. Under T_6 treatment weed population was lower at 30 and 45 DAS as hand weedings at 20 days and 40 days after crop sowing was done. The weed density was nil in most of the cases in early stage of crop growth mainly due to the absence of weed in the experimental plots. Oxyfluorfen 23.5% EC performed better with the presence of lower number of weeds in treated plot. Rate of herbicide application is also an important factor in restricting weed population. With the increment in herbicide application rate, weed density decreased. Oxyfluorfen 23.5% EC @850 ml ha^{-1} proved as best treatment (T_3) with least presence of weeds in the treated plots *i.e*., for better control over weed population. Similar results of oxyflourfen were found in other vegetable crops by Aegerter (2007) and Ramirez *et al.* (2007).

Dry weight of weed

The weeds were first dried in sun and further in an oven at 70 °C for72 hrs species wise at each observation time. With the advancement of duration of experiment, weed dry matter production increased in all treatments except inT_6 treatment, as it included two hand weeding at 20 and 40 days after sowing (Table 4 and 5). Therefore, T_6 gave the best result with least dry weight of weeds throughout the crop growth period. Oxyfluorfen 23.5% EC @ 850 ml ha^{-1} (T_3) proved as second best treatment and was followed by T_4 and T_5 at most of the time. However, T_2 and T_1 were merely effective as higher dry weight of weed was recorded under these two treatments than the other treatments. Highest weed dry weight was found in untreated control (T_7) treatment due to higher weed density and weed growth. Similar results were found by Premitalake *et al*.(2004).

Weed control efficiency

Weed control efficiency (WCE) over untreated control (weedy check) was calculated based on weed dry weight. From the study, (Table 6 and 7) it was noticed that weed control efficiency was found to be higher with the different weed management practices over untreated control(T_7). There was no WCE recorded at 15 DAS due to absence of the specific species except *Chenopodium album* and *Cyperus rotundus.* Almost in all species, T_3 treatment receiving Oxyfluorfen 23.5% EC @850 ml ha^{-1} registered highest WCE at each observation time over other treatments. The variation in WCE among different treatments is mainly due to the variation in number and dry weight of weeds present there. As the rate of application of herbicide Oxyfluorfen 23.5% EC increased, WCE also increased to some extent. Similar results recorded by Shylaja *et al*. (2004).

Table 2: Effect of Oxyfluorfen 23.5% EC on number of weeds/ m² at various crop stage of potato.(Mean of two years)

	Treatment	Doses ml ha^{-1}	*Chenopodium album*				*Cyperusrotundus*			
			15 DAS	**30 DAS**	**45 DAS**	**60 DAS**	**15 DAS**	**30 DAS**	**45 DAS**	**60 DAS**
T_1	Oxyfluorfen 23.5% EC	425	0.71 (0.00)	1.35 (1.33)	1.68 (2.33)	2.48 (5.67)	4.81 (22.67)	5.61 (31.00)	6.18 (37.67)	5.28 (27.33)
T_2	Oxyfluorfen 23.5% EC	650	0.71 (0.00)	1.47 (1.67)	2.04 (3.67)	2.68 (6.67)	5.12 (25.67)	5.85 (33.67)	6.01 (35.67)	5.76 (32.67)
T_3	Oxyfluorfen 23.5% EC	850	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.87 (3.00)	4.10 (16.33)	4.98 (24.33)	4.88 (23.33)	3.94 (15.00)
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	0.71 (0.00)	0.71 (0.00)	1.35 (1.33)	2.27 (4.67)	4.34 (18.33)	5.49 (29.67)	5.67 (31.67)	4.56 (20.33)
T_5	Straw mulch	—	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.96 (3.33)	4.45 (19.33)	5.40 (28.67)	5.46 (29.33)	4.67 (21.33)
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	1.87 (3.00)	1.68 (2.33)	0.71 (0.00)	1.78 (2.67)	5.70 (32.00)	4.71 (21.67)	3.44 (11.33)	6.01 (35.67)
T_7	Untreated control (weedy check)	—	1.96 (3.33)	3.14 (9.33)	3.49 (11.67)	3.76 (13.67)	5.93 (34.67)	6.23 (38.33)	6.57 (42.67)	7.06 (49.33)
	SEm (±)		**0.012**	**0.025**	**0.023**	**0.023**	**0.014**	**0.032**	**0.027**	**0.026**
	LSD(0.05)		**0.039**	**0.078**	**0.071**	**0.073**	**0.043**	**0.101**	**0.083**	**0.080**

Note : Square root transformed data are presented; original data are in parenthesis

Table 3: Effect of Oxyfluorfen 23.5% EC on number of weed/ m^2 of potato at various stage of crop.(Mean of two years)

	Treatment	Doses ml/ha	*Melilotus alba*				*Phalaris minor*			
			15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T_1	Oxyfluorfen 23.5% EC	425	Nil	1.22 (1.00)	1.47 (1.67)	1.68 (2.33)	Nil	1.22 (1.00)	1.68 (2.33)	2.12 (4.00)
T_2	Oxyfluorfen 23.5% EC	650	Nil	0.71 (0.00)	1.58 (2.00)	1.96 (3.33)	Nil	1.47 (1.67)	1.96 (3.33)	2.35 (5.00)
T_3	Oxyfluorfen 23.5% EC	850	Nil	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	Nil	0.71 (0.00)	1.22 (1.00)	1.35 (1.33)
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	Nil	0.71 (0.00)	1.22 (1.00)	1.47 (1.67)	Nil	0.71 (0.00)	1.35 (1.33)	1.78 (2.67)
T_5	Straw mulch	—	Nil	0.71 (0.00)	1.22 (1.00)	1.22 (1.0)	Nil	0.71 (0.00)	0.71 (0.00)	1.58 (2.00)
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	Nil	0.71 (0.00)	0.71 (0.00)	1.58 (2.00)	Nil	0.71 (0.00)	0.71 (0.00)	1.78 (2.67)
T_7	Untreated control (weedy check)	—	Nil	1.68 (2.33)	1.87 (3.00)	2.27 (4.67)	Nil	1.87 (3.00)	2.48 (5.67)	3.08 (9.00)
	SEm (±)			**0.013**	**0.012**	**0.019**		**0.010**	**0.011**	**0.017**
	LSD(0.05)			**0.040**	**0.037**	**0.059**		**0.032**	**0.033**	**0.051**

Note : Square root transformed data are presented; original data are in parenthesis

Table 4: Effect of Oxyfluorfen 23.5% EC on dry weight of weeds (g / m^2) at various crop stage of potato. (Mean of two years)

	Treatment	Doses ml ha^{-1}	*Chenopodium album*				*Cyperus rotundus*			
			15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T_1	Oxyfluorfen 23.5% EC	425	0.71 (0.00)	0.71 (0.00)	0.96 (0.42)	1.44 (1.56)	2.70 (6.77)	2.33 (4.92)	2.44 (5.44)	2.80 (7.35)
T_2	Oxyfluorfen 23.5% EC	650	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.15 (0.83)	2.37 (5.12)	2.07 (3.80)	2.13 (4.04)	2.63 (6.40)
T_3	Oxyfluorfen 23.5% EC	850	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	1.10 (0.72)	2.28 (4.72)	1.62 (2.12)	1.85 (2.93)	2.25 (4.55)
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	0.71 (0.00)	0.99 (0.48)	1.02 (0.54)	1.48 (1.70)	2.77 (7.15)	2.3 (5.06)	2.59 (6.22)	2.89 (7.86)
T_5	Straw mulch	—	0.71 (0.00)	1.01 (0.52)	1.16 (0.84)	1.61 (2.10)	2.47 (5.60)	2.08 (3.82)	2.11 (3.96)	2.47 (5.62)
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	1.07 (0.66)	0.98 (0.46)	0.71 (0.00)	1.06 (0.62)	3.64 (12.76)	2.69 (6.71)	1.97 (3.37)	2.58 (6.15)
T_7	Untreated control (weedy check)	—	1.10 (0.72)	1.76 (2.61)	2.50 (5.73)	3.97 (15.27)	3.79 (13.88)	4.16 (16.82)	4.66 (21.25)	4.96 (24.06)
	SEm (±)		**0.012**	**0.014**	**0.012**	**0.023**	**0.014**	**0.020**	**0.027**	**0.024**
	LSD(0.05)		**0.038**	**0.042**	**0.037**	**0.071**	**0.042**	**0.061**	**0.083**	**0.074**

Note : Square root transformed data are presented; original data are in parenthesis

Table 5: Effect of Oxyfluorfen 23.5% EC on dry weight of weeds (g / m^2) at various crop stage of potato. (Mean of two years)

	Treatment	Doses ml ha^{-1}	*Melilotus alba*				*Phalaris minor*			
			15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T_1	Oxyfluorfen 23.5% EC	425	Nil	0.71 (0.00)	1.40 (1.45)	1.71 (2.42)	Nil	1.12 (0.75)	1.26 (1.10)	1.66 (2.24)
T_2	Oxyfluorfen 23.5% EC	650	Nil	1.02 (0.54)	1.24 (1.04)	1.51 (1.77)	Nil	0.96 (0.42)	1.14 (0.80)	1.57 (1.98)
T_3	Oxyfluorfen 23.5% EC	850	Nil	0.71 (0.00)	0.71 (0.00)	0.71 (0.00)	Nil	0.71 (0.00)	0.71 (0.00)	1.08 (0.67)
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	Nil	0.71 (0.00)	1.07 (0.65)	1.10 (0.70)	Nil	0.71 (0.00)	0.92 (0.35)	1.04 (0.58)
T_5	Straw mulch	—	Nil	0.71 (0.00)	1.10 (0.72)	1.35 (1.32)	Nil	0.71 (0.00)	1.06 (0.62)	1.17 (0.87)
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	Nil	0.71 (0.00)	0.71 (0.00)	1.48 (1.70)	Nil	0.71 (0.00)	0.71 (0.00)	1.19 (0.92)
T_7	Untreated control (weedy check)	—	Nil	1.70 (2.38)	2.58 (6.15)	3.19 (9.66)	Nil	2.27 (4.67)	2.47 (5.60)	3.23 (9.94)
	SEm (±)			**0.013**	**0.019**	**0.021**		**0.017**	**0.018**	**0.027**
	LSD(0.05)			**0.039**	**0.058**	**0.064**		**0.051**	**0.056**	**0.082**

Note : Square root transformed data are presented; original data are in parenthesis

Table 6: Effect of Oxyfluorfen 23.5% EC on weed control efficiency at various crop stage of potato. (Mean of two years)

	Treatment	Doses ml ha^{-1}	*Chenopodium album*				*Cyperusrotundus*			
			15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T_1	Oxyfluorfen 23.5% EC	425	100.00	81.61	90.58	88.87	51.22	70.75	74.40	69.45
T_2	Oxyfluorfen 23.5% EC	650	100.00	100.00	92.67	89.78	63.11	77.41	80.99	73.40
T_3	Oxyfluorfen 23.5% EC	850	100.00	100.00	100.00	95.28	65.99	87.40	86.21	81.09
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	100.00	80.08	85.34	86.25	48.49	69.92	70.73	67.33
T_5	Straw mulch	—	100.00	100.00	100.00	94.56	59.65	77.29	81.36	76.64
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	8.33	82.38	100.00	95.94	8.07	60.11	84.14	74.44
T_7	Untreated control (weedy check)	—	—	—	—	—	—	—	—	—

Table 7: Effect of Oxyfluorfen 23.5% EC on weed control efficiency at various crop stage of potato. (Mean of two years)

	Treatment	Doses ml ha^{-1}	*Melilotus alba*				*Phalaris minor*			
			15 DAS	30 DAS	45 DAS	60 DAS	15 DAS	30 DAS	45 DAS	60 DAS
T_1	Oxyfluorfen 23.5% EC	425	Nil	77.31	83.09	81.68	Nil	91.01	85.71	80.08
T_2	Oxyfluorfen 23.5% EC	650	Nil	100.00	88.29	86.34	Nil	100.00	88.93	91.25
T_3	Oxyfluorfen 23.5% EC	850	Nil	100.00	100.00	100.00	Nil	100.00	93.75	94.16
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	Nil	100.00	76.42	74.95	Nil	83.94	80.36	77.46
T_5	Straw mulch	—	Nil	100.00	89.43	92.75	Nil	100.00	100.00	93.26
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	Nil	100.00	100.00	82.40	Nil	100.00	100.00	90.74
T_7	Untreated control (weedy check)	—	—	—	—	—	—	—	—	—

Table 8: Effect of Oxyfluorfen 23.5% EC on growth and yield parameters of potato. (Mean of two years)

	Treatment	Doses ml ha^{-1}	Plant height (cm)	No. of leaves plant^{1}	Dry wt of haulms (g m^2)	Total dry matter production (g m^2)	Total no of tubers (10^3 ha^{-1})	Total yield (t ha^{-1})
T_1	Oxyfluorfen 23.5% EC	425	63.72	92.34	168.2	746.7	523.9	22.72
T_2	Oxyfluorfen 23.5% EC	650	65.24	98.61	174.6	757.4	525.7	23.83
T_3	Oxyfluorfen 23.5% EC	850	69.51	121.27	180.7	766.2	528.3	25.43
T_4	Metribuzin 70% WP	0.75 kg ha^{-1}	61.46	88.46	164.3	743.8	522.8	21.26
T_5	Straw mulch	—	66.20	118.36	176.1	762.6	526.1	22.18
T_6	Two hand weedings at 20 and 40 days after sowing (Weed free check)	—	71.16	127.52	182.3	778.3	530.5	25.80
T_7	Untreated control (weedy check)	—	59.44	85.38	162.8	741.3	519.5	18.55
	SEm (±)		**0.75**	**1.22**	**0.26**	**1.76**	**2.20**	**1.00**
	LSD(0.05)		**2.31**	**3.74**	**0.79**	**5.43**	**6.78**	**3.08**

Growth, yield attributes and yield of potato

Experimental results (Table 8) showed that various weed management practices including herbicidal treatments significantly influenced the growth attributes as well as yield attributes and yield of potato. Treatment receiving hand weeding at 20 and 40 days after crop sowing (T_6) significantly had highest plant height (71.16 cm), number of leaves per plant (127.52) and dry weight of haulm(182.3 g m^{-2}). This treatment was followed by T_3 $T_5$and T_2 treatments. This happened mainly due to better control over weed population under T_6 treatment during critical period of crop-weed competition. The lowest result was noticed with the treatment untreated control (T_7). Highest dry weight of tubers was registered with the treatment T_6. The second higher result was recorded with T_3 producing 2.34 per cent higher tuber dry weight over T_2 treatment. Treatment T_6 significantly registered highest total dry matter to the tune of 2.06 and 5.00 per cent higher over T_5 and T_7, respectively. Potato plots treated with T_6 significantly produced highest number of tubers per ha and was followed by T_3 whereas the lowest was recorded with T_7. Treatment comprised of hand weeding at 20 and 40 days after crop sowing (T_6) maintained its superiority with highest total tuber yield (25.80 t ha^{-1}). Plots sprayed with Oxyfluorfen 23.5% EC @ 850 ml ha^{-1} (T_3) produced 6.71, 11.93, 14.65 and 19.61per cent higher tuber yield over T_2, T_1,T_5 andT_4, respectively and proved as second best treatment. Overall Oxyfluorfen 23.5% EC applied @ 850 ml ha^{-1} was highly effective in controlling weeds and subsequently producing higher potato tuber yield as compared to untreated control (weedy check).

Phytotoxicity

There has been no phytotoxic effect whatsoever in potato at different doses of oxyfluorfen used in the study. From the experiment, it is concluded that among the different treatments, hand weeding at 20 and 40 days after crop sowing maintained its superiority with highest control of weeds and crop yield. Among herbicidal treatments, Oxyfluorfen 23.5% EC @ 850 ml ha^{-1} showed higher efficiency in controlling weeds with lowest number and dry weight of weeds after weed free check system. Therefore, the use of Oxyfluorfen 23.5% EC @ 850 ml ha^{-1} can be suggested for the check of weeds in potato crop.

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