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Efficiency of Different Herbicides Alone and their Combination with Optimum time of Application to Control Weeds in Potato (*Solanum tuberosum* L.) in Haryana

Raj Kumar*, A.K. Bhatia and Davinder Singh

Department Of Vegetable Science, College Of Agriculture,
CCS Haryana Agricultural University, Hisar-125004, India.

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The experiment was conducted during Rabi season of 2013-14 to study the efficacy of different herbicides alone and their combination to control weeds in potato crop. Among the different herbicides studied pre-emergence application of atrazine @250 g/ha alone have been found more efficient in controlling both monocot and dicot weeds with higher weed control efficiency (99.1%) as compared to atrazine @125 g/ha with metribuzin@175 g/ha as pre-emergence and with paraquat@35 g/ha as post-emergence. The maximum potato yield, nutrient uptake by potato crop and minimum nutrient uptake by weeds was recorded in weed free (425.8q/ha) while pre-emergence application of atrazine @250 g/ha gave higher significant results followed by pendimethalin@1000g/ha as pre-emergence. However, maximum nutrient uptake by weeds was recorded with weedy check. The highest benefit: cost ratio was noticed in atrazine @250 g/ha pre-emergence (2.72) compared to other herbicides and conventional weed management practices.

Keywords: Weed, Efficacy, Yield, Herbicide, Potato**.**

Potato (*Solanum tuberosum* L.) is a native of high Andean region of South America. It is believed that it has been brought to India first by Portuguese in the 17thCentury. Potato is one of the most important crops grown throughout the world and the third major food crop after wheat and rice. It is a good source of carbohydrates and used as staple food in many countries. Potato produces highest dry matter, carbohydrates, edible protein, minerals and vitamins per unit area and time among the major food crops. It is wholesome, nutritious and versatile food, which can come to rescue of developing countries for alleviating hunger and malnutrition especially in view of the shrinking land resources. India is third largest producer of potato in the world after China and Russia and occupies 19.73 lakh hectares with the production of 41.5 lakh tones (Anonymous, 2014). About 80 per cent of the potato crop is grown under short day conditions. Potato is an important vegetable crop of Haryana also. It occupies a premier position in both area and production, which ranks first in production and third in area among vegetable crops.

The area and production of potato during 2014 was 30000 hectares and 6.96 lakh tones, respectively (Anonymous, 2014) however, the productivity of crop is still lower (232.0 q/ha) than the potential yield. There are number of factors

* To whom all correspondence should be addressed.
Tel.: +918901282852;
E-mail: rajdharival@gmail.com

that play an important role in deciding the productivity and quality of the produce.

There are many factors, which affect the yield and quality of potato. Several high yielding varieties have been developed, number of agronomical trials on planting time, spacing, nutritional requirement, water management and weed control have been conducted to increase the production. Among these weed control is one of the most important factors.

The competition of weeds with crop plants for moisture, nutrients, light and space reduce the potato yield considerably. Weed competition also reduce the potato quality, affecting tuber size and weight. Weeds interfere with harvest, causing more potato to be left in the field and increasing mechanical injuries. If a mixed population of annual weeds is allowed to compete with crop then each 10 per cent increase in dry weed biomass causes a 12 per cent decrease in tuber yield.

During the past few years, research on chemical weed control has progressed rapidly and herbicides are now being used widely in all technologically developed potato growing countries. It is not possible to keep the crop free of weeds without some soil disturbances. However, chemical weed control greatly reduces yield loss and it is regarded as a useful supplement to mechanical weed control. Some new potato varieties have been developed and some new chemical are available in market, which have yet been tested in potato.

The usual method of controlling weeds (hand weeding and earthing up) in potato is although effective but time consuming, uneconomical and damaging to the crop roots. The weed flora is dynamic in both intensity and speciation, which is influenced by location, cropping system and climatic conditions etc. Herbicides therefore need to be evaluated from locality to locality. No single herbicide can be taken for granted to solve weed problem in the same crop in different agro-climatic conditions.

In such situation, use of herbicide for weed control becomes essential. Some experiments have shown the efficacy of certain herbicides to control weeds. Management of weeds within economic threshold level is pertinent part of production technologies for vegetable crops. The weeds can cause productivity losses up to 80 per cent in potato, depending on agro-economical zones and crop management practices. Further, the weeds also serve as an alternate and collateral host to major potato disease pathogens and pests. Therefore, the present study was undertaken to judge the potentiality of certain herbicides alone and in combination with each other for controlling weeds in potato cv. Kufri Bahar with the following objectives:-

1. To find out the optimum time of application of herbicides to control weeds
2. To test the efficacy of different herbicides alone and their combination to control weeds in potato

MATERIAL AND METHODS

The experiment was laid out in the experimental farm of the Department of Vegetable Science of Chaudhary Charan Singh Haryana Agricultural University, Hisar (Haryana) located at 29^0 10' latitude north and 75° 46' longitude east at sea mean elevation of 215.2 m above the mean sea level. The climate of Hisar region is semi-arid characterized by hot and dry winds accompanied by frequent dust storms of high velocity during summer months and dry and severe cold conditions during winter. Maximum temperature of 48^0C is not uncommon during summer, while temperature around freezing point accompanied by occurrence of frost in winter is very common. The mean annual rainfall is 425 mm and total rain as well as its distribution is subjected to great variation. The rainfall mainly confined to monsoon months, i.e. July to September with occasional light showers during winter and spring months. The soil of experimental field was uniform in fertility and sandy loam in texture. Soil samples of 0.30 m soil depth were taken from five places in *zig-zag* manner from the field before layout of the experiment. The soil of five places mixed thoroughly. The physio-chemical study of soil sample was done with appropriate method. The experiment was laid out in randomized block design. The net plot size was (3.6 x 3.6 m) and potato tubers of *cv*. Kufri Bahar were planted at 60×20 cm spacing in the last week of October. Farm yard manure (FYM) @ 50 t/ha was applied prior to field preparation and full dose of phosphorus and potash were applied as basal dose. The study was laid out with 13 treatments in

randomized block design and replicated thrice. potato cv. Kufri Bahar was treated with different treatment combinations *viz.* T1 Paraquat 750 g/ha pre-emergence, T2: Pendimethalin 1000 g/ha pre-emergence, T3 Oxyflurfen 100 g/ha followed by penoxadin 50 g/ha pre-emergence, T4: Metribuzin 350 g/ha pre-emergence T5: Metribuzin 350 g/ha post-emergence at 10% germination, T6 Atrazine 250 g/ha pre-emergence, T7: Atrazine 125 g/ha + Metribuzin 175 g/ha pre-emergence, T8: Atrazine 125 g/ha + Paraquat 35 g/ha post-emergence, T9 : Hand weeding at 30 DAS and weed free later, T10: Hand weeding at 40 DAS and weed free later, T11 : Hand weeding at 50 DAS and weed free later, T12: Weed free and T13: Weedy check. The name and number of (dicot and monocot) weeds, weed control efficiency, NPK removal by weeds and potato crop, plant height, tuber yield was recorded.

Name and number of (dicot and monocot) weeds

At the beginning of the experiment, the weeds were identified and grouped into dicot and monocot species and permanent quadrants of $1m^2$ were fixed at random in each plot. Observations on periodic weed population counts was recorded at 1m square area at 100 days after planting in all the treatments except hand weeding where weed sample were collected at 30, 40, 50 days after planting.

Weed control efficiency

Weed control efficiency was calculated by the following formula given as below:

$$\text{WCE (\%)} = \frac{\text{D.W. of weed in weedy check - D.W. of weed in treatment}}{\text{D.W. of weed in weedy check}} \times 100$$

Nutrients uptake by potato crop

Nutrient uptake was calculated by multiply the nutrient contents in leaf sample with dry weight of haulm and dividing by hundred and then expressed as kg per ha.

$$\text{Nutrients uptake by haulm (kg/ha)} = \frac{\text{Nutrient contents in haulm (\%)} \times \text{Dry Weight of haulm (kg/ha)}}{100}$$

Similarly, nutrient uptake by potato tuber was derived with same formula. Then total nutrient uptake by potato crop was the sum of nutrients uptake by potato haulm and tuber.

Nutrients uptake by weeds

Nutrient uptake by weeds was calculated by multiply the nutrient contents in leaf sample with oven dry weight of weeds and dividing by hundred and expressed as kg per ha.

$$\text{Nutrients uptake by weeds (kg/ha)} = \frac{\text{Nutrient contents in weeds (\%)} \times \text{Dry weight of weed (kg/ha)}}{100}$$

Plant height

Ten plants were selected randomly from each plot. The height of these plants was recorded in centimeter (cm) at 30, 40, and 50 and 100 days after planting from base to the apex of last leaf and average was worked out.

Tuber yield (q/ha)

Total yield was obtained by summing up the weight of tubers in kilogram per plot. The values were later converted to quintal per hectare.

RESULTS AND DISCUSSION

Name and number of (dicot and monocot) weeds

The dominating dicot weeds in the experimental field of potato were gajri (*Fumaria parviflora)*, bathu (*Chenopodium album*), hiran khuri (*Convolvulus arvensis*), senji (*Melilotus alba*) and choulai (*Amaranthus* spp.) whereas, motha (*Cyperus rotundus*), pyaji (*Asphodelus tenuifolius*) and kandai (*Rumex* spp.) were the most prominent monocot weeds under Hisar conditions. Similar results have also been reported by Singh *et al.* (2010), Singh *et al.* (2006) and Kumar (1998) in potato crop. The number of weeds recorded at 100 days after planting were maximum in the treatment weedy check (147.6 and 41.6/m^2 dicot and monocot weed, respectively) presented in Table 1 as no check measures were taken in this case and weeds grew uninterruptedly followed by paraquat @ 750 g/ha as pre-emergence (99.6 and 18.6/m^2). Among herbicidal treatments, significantly minimum number of weeds was found with atrazine @ 250 g/ha as pre-emergence (12.0 and 11.6/m^2) followed by pendimethalin @ 1000 g/ha (13.6 and 15.3/m^2) as pre-emergence (Tomar *et al*. 2008). The population of dicot and monocot weed was controlled by all the herbicidal treatments except paraquat 750 g/ha applied as pre-emergence which slightly reduced the population in early stage of

crop growth, as paraquat is a post-emergence contact herbicide and kills all the vegetation, which come in its contact. Similar results have also been reported by Singh *et al.* (2014), Pramanick *et al.* (2012), Singh *et al.* (2007), Rana *et al.* (2005) and Sandhu *et al.* (1976).

Weed control efficiency

Among the herbicidal treatments, significantly weed control efficiency (99.1%) was recorded maximum in atrazine @ 250 as pre-emergence closely followed by pendimethalin (98.1%) and metribuzin (96.5%) as pre-emergence (Sharma *et al.* 2004). Lowest weed control efficiency (32.3%) was recorded in treatment paraquat @ 750 g/ha applied as pre-emergence (Table 2). The efficiency of all the herbicides in controlling weeds decreased with delay in their application.

Plant height

The perusal of data presented in Table 3 indicates that different treatments significantly affected the plant height at different stages of plant growth i.e., 30, 40, 50 and 100 DAP. In general, the plant height increased with the advancement in crop age and the increase was pronounced at 40 DAP. Maximum plant height (32.5,36.0,43.3 and 59.8 cm, respectively) at 30, 40, 50 and 100 days after planting was recorded in weed free followed by the treatment with atrazine @ 250 g/ha applied as pre-emergence (29.7,34.3, 41.7 and 59.2 cm, respectively) by pendimethalin @ 1000 g/ha as pre-emergence (28.6, 33.0, 40.6 and 57.8 cm, respectively) which were at par. Whereas minimum plant height (17.5, 21.4, 27.9 and 45.7 cm, respectively) was recorded with weedy check treatment closely followed by paraquat @ 750 g/ha as pre-emergence (19.7, 23.5, 32.3 and 47.8 cm, respectively) and hand weeding at 50 DAP and weed free later (20.4, 26.0, 32.5 and 48.6 cm, respectively).

Among herbicidal combinations, oxyflurfen @100 g/ha + penoxadin @ 50 g/ha as pre-emergence treated plots gave taller plants (26.8, 30.0, 37.0 and 56.1 cm, respectively) as compared to atrazine @ 125 g/ha + paraquat @ 35 g/ha as post-emergence (24.2, 29.4, 34.7 and 55.2 cm, respectively), atrazine @ 125 g/ha + metribuzin @175 g/ha as pre-emergence (23.5, 28.8, 33.9 and 54.1 cm, respectively) however these were statistically at par.

Nutrient removal (NPK) removal

Weed control treatments were also effect the nutrient uptake by weed. Significantly minimum

Table 1. Effect of weed control treatments on total number of weeds

Treatments / herbicides (g/ha)	Number of total weeds/ sq. m.		
	No. of monocot weed	No. of dicot weed	Total No. of weeds
Paraquat (750) pre-emergence	18.6 (4.4)	99.6 (10.0)	118.2 (10.9)
Pendimethalin (1000) pre-emergence	15.3 (4.0)	13.6 (3.8)	28.9 (5.5)
Oxyflurfen(100) + penoxadin (50) pre-emergence	18.0 (4.3)	23.6 (5.0)	41.6 (6.5)
Metribuzin (350) pre-emergence	16.3 (4.1)	15.6 (4.1)	31.9 (5.7)
Metribuzin (350) post-emergence	16.6 (4.2)	19.6 (4.5)	36.2 (6.0)
Atrazine (250) pre-emergence	11.6 (3.6)	12.0 (3.6)	23.6 (5.0)
Atrazine (125) + metribuzin (175) pre-emergence	19.3 (4.5)	26.3 (5.2)	45.6 (6.8)
Atrazine (125) + paraquat (35) post-emergence	18.6 (4.4)	25.0 (5.1)	43.6 (6.7)
Hand weeding at 30 DAP* and weed free later	24.6 (5.1)	37.0 (6.1)	61.6 (7.9)
Hand weeding at 40 DAP* and weed free later	27.3 (5.3)	38.2 (6.2)	65.5 (8.2)
Hand weeding at 50 DAP* and weed free later	32.6 (5.8)	60.0 (7.8)	92.6 (9.7)
Weed free	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Weedy check	41.6 (6.5)	147.6 (12.2)	189.2 (13.8)
SEm ±	0.1	0.1	1.6
C.V. (%)	4.6	3.0	5.6
C.D. at 5%	0.3	0.3	4.0

DAP – Days after planting

The values given in the parentheses are square root (x+1) transformed values

Table 2. Effect of weed control treatments on dry matter production of weed and weed control efficiency

Treatments/ herbicides (g/ha)	Fresh weight (g/m^2)	Dry weight (g/m^2)	Dry matter (%)	Weed control efficiency (%)
Paraquat (750) Pre-emergence	1430.2 (37.8)	396.4(19.9)	27.7 (5.4)	32.3 (5.8)
Pendimethalin (1000) Pre-emergence	115.2 (10.8)	10.8 (3.4)	9.4 (3.2)	98.1 (10.0)
Oxyflurfen (100) + Penoxadin (50) Pre-emergence	274.1 (16.6)	45.6 (6.8)	16.6 (4.2)	92.2 (9.7)
Metribuzin (350) Pre-emergence	133.2 (11.6)	20.5 (4.6)	15.4 (4.0)	96.5 (9.9)
Metribuzin (350) Post-emergence	203.6 (14.3)	33.4 (5.9)	16.4 (4.2)	94.3 (9.8)
Atrazine (250) Pre-emergence	95.1 (9.8)	5.8 (2.6)	6.1 (2.7)	99.1 (10.0)
Atrazine (125) +Metribuzin (175) Pre-emergence	370.0 (19.3)	68.0 (8.3)	18.4 (4.4)	88.3 (9.4)
Atrazine (125) + Paraquat (35) Post-emergence	304.2 (17.5)	54.4 (7.4)	17.9 (4.3)	90.7 (9.6)
Hand weeding at 30 (DAP)* and weed free later	690.0 (26.3)	131.8(11.5)	19.1 (4.5)	77.5 (8.9)
Hand weeding at 40 (DAP)* and weed free later	1027.3 (32.1)	205.5 (14.4)	20.0 (4.6)	64.9 (8.1)
Hand weeding at 50 (DAP)* and weed free later	1138.2 (33.8)	263.7 (16.3)	23.2 (4.9)	55.0 (7.5)
Weed free	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	100.0 (10.0)
Weedy check	1648.2 (40.6)	586.1 (24.2)	35.6 (6.0)	0.0 (1.0)
SEm±	2.9	3.9	1.0	0.7
C.V. (%)	4.5	3.4	3.2	3.1
C.D. at 5%	11.4	8.1	2.5	1.8

DAP - Days after planting. The values given in the parentheses are square root (x+1) transformed values

Table 3. Effect of weed control treatments on plant height

Treatments/ herbicides (g/ha)	Plant height (cm)			
	30 DAP	40 DAP	50 DAP	100 DAP
Paraquat (750) pre-emergence	19.7	23.5	32.3	47.8
Pendimethalin (1000) pre-emergence	28.6	33.0	40.6	57.8
Oxyflurfen (100) + penoxadin (50) PE	26.8	30.0	37.0	56.1
Metribuzin (350) pre-emergence	28.3	32.2	39.4	57.2
Metribuzin (350) post-emergence	27.9	31.6	38.4	56.6
Atrazine (250) pre-emergence	29.7	34.3	41.7	59.2
Atrazine (125) + metribuzin (175) PE	23.5	28.8	33.9	54.1
Atrazine (125) + paraquat (35) post-emergence	24.2	29.4	34.7	55.2
Hand weeding at 30 DAP*and weed free later	22.9	28.0	33.4	51.3
Hand weeding at 40 DAP* and weed free later	21.6	27.6	33.0	50.5
Hand weeding at 50 DAP*and weed free later	20.4	26.0	32.5	48.6
Weed free	32.5	36.0	43.3	59.8
Weedy check	17.5	21.4	27.9	45.7
SEm ±	1.3	0.9	1.6	1.9
C.V. (%)	9.1	5.6	7.7	6.1
C.D. at 5%	3.9	2.8	4.7	5.5

DAP- Days after planting

nitrogen, phosphorus and potassium uptake by weeds was recorded with weed free treatment closely followed by atrazine @ 250 g/ha as pre-emergence (0.7 kg/ha, 0.1 kg/ha and1.2 kg/ha, respectively) and pendimethalin @ 1000 as pre-emergence (1.9 kg/ha, 0.2 kg/ha and 2.4 kg/ha, respectively), metribuzin @ 350 g/ha as pre-emergence (4.0 kg/ha, 0.5 kg/ha and 4.8 kg/ha, respectively) and metribuzin @ 350 g/ha as post-emergence (6.9 kg/ha, 0.8 kg/ha and8.1 kg/ha, respectively). However, significantly maximum N, P and K uptake by weed was recorded with weedy

Table 4 (a). Effect of weed control treatments on nutrients uptake by weeds

Treatments/ herbicides (g/ha)	N(kg/ha)	P(kg/ha)	K(kg/ha)
Paraquat (750) pre-emergence	113.4 (10.7)	13.1 (3.8)	112.8 (10.7)
Pendimethalin (1000) pre-emergence	1.9 (1.1)	0.2 (1.1)	2.4 (1.8)
Oxyflurfen (100)+ penoxadin (50) pre-emergence	10.2 (3.3)	1.2 (1.5)	11.4 (3.5)
Metribuzin (350) pre-emergence	4.0 (2.2)	0.5 (1.2)	4.8 (2.4)
Metribuzin (350) post-emergence	6.9(2.8)	0.8 (1.3)	8.1 (3.0)
Atrazine (250) pre-emergence	0.7 (1.3)	0.1 (1.0)	1.2 (1.5)
Atrazine (125) + metribuzin (175) pre-emergence	18.2(4.4)	1.9 (1.7)	17.9 (4.3)
Atrazine (125) + paraquat (35) post-emergence	12.7 (3.7)	1.5 (1.6)	14.0 (3.9)
Hand weeding at 30 (DAP)* and weed free later	35.7(6.1)	3.7 (2.2)	35.6 (6.0)
Hand weeding at 40 (DAP)* and weed free later	57.1 (7.6)	6.2 (2.7)	56.4 (7.6)
Hand weeding at 50 (DAP)* and weed free later	76.7 (8.8)	8.2 (3.0)	74.4 (8.7)
Weed free	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Weedy check	172.1 (13.2)	20.5 (4.6)	171.7 (13.1)
SEm ±	0.9	0.3	0.9
C.V. (%)	12.8	8.4	4.2
C.D. at 5%	2.6	0.9	2.5

DAP- Days after planting

Table 4(b). Effect of weed control treatments on nutrients uptake by potato crop (haulm + tuber)

Treatments / herbicides (g/ha)	N(kg/ha)	P(kg/ha)	K(kg/ha)
Paraquat (750) pre-emergence	49.0	3.5	68.0
Pendimethalin (1000) pre-emergence	269.2	30.6	293.6
Oxyflurfen(100)+ penoxadin (50) pre-emergence	192.3	18.9	213.8
Metribuzin (350) pre-emergence	260.1	26.9	278.9
Metribuzin (350) post-emergence at 10% germination	213.1	20.8	226.7
Atrazine (250) pre-emergence	276.9	32.4	298.9
Atrazine (125) + metribuzin (175) pre-emergence	158.0	13.4	177.7
Atrazine (125) + paraquat (35) post-emergence	175.1	16.4	195.7
Hand weeding at 30 (DAP)* and weed free later	129.2	10.2	144.2
Hand weeding at 40 (DAP)* and weed free later	117.9	8.0	131.7
Hand weeding at 50 (DAP)* and weed free later	90.9	6.8	121.4
Weed free	294.6	35.1	317.9
Weedy check	35.6	1.9	48.2
SEm ±	1.7	1.4	1.9
C.V. (%)	6.8	4.2	7.2
C.D. at 5%	41.6	9.4	42.1

DAP - Days after planting

check treatment (Table 4 a). These results are conformity with Singh *et al.* (2010), Pramanick *et al* (2012) and Chandresh *et al.* (2014).

Data pertaining to nitrogen up take by potato crop as given in Table (4 b) revealed that significantly maximum nitrogen (294.6 kg/ha) uptake by potato crop was recorded with weed free treatment closely followed by atrazine @ 250 g/ha pre-emergence (276.9 kg/ha), pendimethalin @ 1000 g/ha as pre-emergence (269.2 kg/ha) and metribuzin @ 350 g/ha as pre-emergence (260.1 kg/ha). However minimum nitrogen (35.6 kg/ha) uptake by potato crop was recorded in weedy check treatment closely followed by paraquat @ 750 g/ha as pre-emergence (49.0 kg/ha).

Similarly, the maximum phosphorus (35.1 kg/ha) uptake by potato crop was found with weed free treatment closely followed by atrazine @ 250 g/ha pre-emergence (32.4 kg/ha), pendimethalin @ 1000 g/ha as pre-emergence (30.6 kg/ha) and metribuzin @ 350 g/haas pre-emergence (26.9 kg/ha). Significantly, the minimum phosphorus (1.9 kg/ha) uptake by potato crop was showed by weedy check treatment and closely followed by paraquat @ 750 g/ha as pre-emergence (3.5 kg/ha), hand weeding at 50 DAP and weed free later (6.8 kg/ha), hand weeding at 40 DAP and weed free later (8.0 kg/ha) and hand weeding at 30 DAP and weed free later (10.2 kg/ha).

While significantly, maximum potassium (317.9 kg/ha) uptake by potato crop was recorded with weed free treatment closely followed by atrazine @ 250 g/ha pre-emergence (298.9 kg/ha), pendimethalin @ 1000 g/ha as pre-emergence (293.6 kg/ha) and metribuzin @ 350 g/ha as pre-emergence (278.9 kg/ha) whereas, minimum potassium (48.2 kg/ha) uptake by potato crop was recorded in weedy check treatment closely followed by paraquat @ 750 g/ha as pre-emergence (68.0 kg/ha).

Tuber yield (q/ha)

The perusal of data presented in Table 5 revealed that total tuber yield was significantly influenced by different weed control treatments. In general, application of various herbicides as pre-emergence recorded more tuber yield. The application of herbicides as post-emergence reduced the yield significantly in comparison to pre-emergence application of herbicides.

Highest total tuber yield (425.8 q/ha) was recorded under weed free treatment closely followed by atrazine @ 250 g/ha applied as pre-emergence (403.5 q/ha), pendimethalin @ 1000 as pre-emergence (394.0 q/ha) and metribuzin @ 350 g/ha as pre-emergence (378.2 q/ha) which were statistically at par (Sharma *et al.* 2004). Significantly minimum tuber yield was recorded under weedy

Table 5. Effect of weed control treatments on tuber yield

Treatments/ herbicides (g/ha)	Time of application	Tuber yield (q/ha)	B:C ratio
Paraquat (750)	Pre-emergence	195.0	0.80
Pendimethalin (1000)	Pre-emergence	394.0	2.63
Oxyflurfen (100) + penoxadin (50)	Pre-emergence	296.7	1.70
Metribuzin (350)	Pre-emergence	378.2	2.46
Metribuzin (350)	Post-emergence at 10% germination	302.3	1.76
Atrazine (250)	Pre-emergence	403.5	2.72
Atrazine (125) + metribuzin (175)	Pre-emergence	252.2	1.32
Atrazine (125) + paraquat (35)	Post-emergence	276.4	1.55
Hand weeding and weed free later	30 (DAP)*	234.2	1.14
Hand weeding and weed free later	40 (DAP)*	223.0	0.74
Hand weeding and weed free later	50 (DAP)*	212.9	0.75
Weed free	-	425.8	2.08
Weedy check	-	131.7	0.23
SEm ±	-	16.7	
C.V. (%)	-	10.1	
C.D. at 5%	-	49.1	

check treatment (131.7 q/ha) where weeds were allowed to grow throughout the growing season followed by paraquat @ 750 g/ha as pre-emergence (195.0 q/ha), however differed significantly. Similar results have also been reported by Naik *et al.* (2003) and Arora *et al.* (2009.

Economics

The comparative economics of different weed control treatments is presented in Table 5. Economics of potato crop production indicated that among different treatments, atrazine @ 250 g/ha applied as pre-emergence showed highest net return and profitability of crop followed by pendimethalin @ 1000 g/ha as pre-emergence and metribuzin @ 350 g/ha as pre-emergence. Maximum benefit to cost ratio was recorded in the treatment atrazine @ 250 g/ha pre-emergence which was 2.72 (Sharma *et al.* 2004) followed by pendimethalin @ 1000 g/ha as pre-emergence (2.63) and metribuzin @ 350 g/ha as pre-emergence (2.46). Weed free treatment exhibited 2.08 benefits: cost ratio while the weedy check showed minimum (0.23).

CONCLUSION

From the present study, it is concluded that the herbicide atrazine @ 250 g/ha applied as pre emergence was found most effective in controlling the weeds and produced maximum tuber yield (425.8q/ha) with weed control efficiency (99.1%) and B: C ratio (2.72)

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