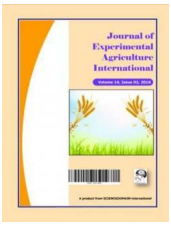

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Conventional Weed Management Practice in Potato (*Solanum tuberosum* L.) with Optimum Time of Application

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Authors' contributions

This research work was carried out in collaboration between all authors. Author RK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AKB and DS helped to manage the analysis of the study. Author DS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Field experiment was conducted during Rabi season of 2013-14 to evaluate the effect of weed management in potato with conventional method. There were five treatments viz. - Hand weeding @ 30 DAP, 40 DAP and 50 DAP, Weed free and weedy check. Among all treatments maximum tuber yield, plant height and nutrient uptake by potato haulm and tuber were recorded with weed free treatment followed by hand weeding at 30 DAP. While minimum tubers yield, plant height and nutrient uptake were recorded with weedy check treatment. Maximum numbers of weeds were recorded with weedy check treatment. *Fumaria parviflora* Lam. (dicot weed) and *Chenopodium album* L. (monocot weed) were found most prominent weed among different type of weed flora observed in experimental field.

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1. INTRODUCTION

Potato is one of the most important commercial vegetable crops widely grown in India. Potato has become a staple food in many parts of the world and an integral part of much of the world's food supply. It is the world's fourth-largest food crop, following maize, wheat, and rice. 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 [1-4]. 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. It has been reported that the presence of weeds throughout the growing season caused 62% reduction in tuber yield [5]. 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 [6]. Farmers have struggled with the presence of weeds in their fields since the beginning of agriculture. Weeds can be considered a significant problem because they tend to decrease crop yields by increasing competition for water, sunlight and nutrients while serving as host plants for pests and diseases. Since the invention of herbicides, farmers have used these chemicals to eradicate weeds from their fields. Using herbicides not only increased crop yields but also reduced the labor required to remove weeds. Today, some farmers have a renewed interest in organic methods of managing weeds since the widespread use of agro-chemicals has resulted in purported environment and health problems. It has also been found that in some cases herbicides use can cause some weed species to dominate fields because the weeds develop resistance to herbicides. In addition, some herbicides are capable of destroying weeds that are harmless to crops, resulting in a potential decrease in biodiversity on farmers. It is important to understand that under an organic system of seed control, weeds will never be eliminated but only managed. The yield reduction due to weeds in potato is estimated to be as high as 10 to 80 per cent [7,8]. So, control of weeds in the initial stages appears imperative as it plays an important role in maximizing the tuber production. The use of clean seed, mowing weeds around the edges of fields or after harvest to prevent weeds from going to seed, and thoroughly composting manure before application can greatly reduce the introduction of weed seeds and difficult weed species. It is even possible to selectively hand-eradicate isolated outbreaks of new weeds, effectively avoiding future infestations. Planting clean, high-quality seed is essential to crop success. Other sanitation factors to consider would include thorough cleaning of any machinery which might have been used in weedy fields, and the establishment of hedgerows to limit windblown seeds. Nitrogen fertilizer can affect the competition between crops and weeds and in the subsequent crops. For example, nitrate is known to promote seed germination and seed production in some weed species. Nitrogen fertilization may result in increased weed growth instead of increased crop yield. Selective placement of nitrogen in a band can favor the crop over the weed. Use of legume residues are opposed to chemical nitrogen fertilizer to supplement nitrogen needs of the crop can enhance weed suppression. Legume released nitrogen slowly with less stimulation of unwanted weed growth. Avoiding pre-plant broadcasting of soluble nutrients because it may be more readily utilized by fast-growing weeds than slow-growing crops, and may even stimulate weed germination. In pre-germination irrigation or rainfall germinates weed seeds just before the cash crop is planted. The newly germinated weeds can be killed by light cultivation or flaming. Pre-germination should occur as close as possible to the date of planting to ensure that changes in weather conditions do not have an opportunity to change the spectrum of weeds (cool vs. warm season) in the field. Mechanical removal of weeds is both time consuming and labor-intensive but is the most effective method for managing weeds. The choice of implementation, timing, and frequency will depend on the structure and form of the crop and the type and number of weeds. Cultivation involves killing emerging weeds or burying freshly shed weed seeds below the depth from which they germinate. It is important to remember that any ecological approach to weed management begins and ends in the soil

seed bank. The sol seed bank is the reserve of weed seeds present in the soil. Observing the composition of the seed bank can help a farmer make practical weed management decisions. Burial to 1 cm depth and cutting at the soil surface are the most effective ways to control weed seedlings mechanically [9]. Mechanical weeding include cultivating tools such as hoes, harrows, tines and brush weeders, cutting tools like mowers and stimmers, and dual-purpose implements like thistle-bars. The choice of implement and the timing and frequency of its use depends on the morphology of the crop and the weeds. Implements such as fixed harrows are more suitable for arable crops, whereas inter-row brush weeders are considered to be more effective for horticultural use. The brush weeder is mainly used for vegetables such as carrots, beetroot, onions, garlic, celery and leeks. The optimum timing for mechanical weed control is influenced by the competitive ability of the crop and the growth stage of the weeds [10-13]. Hand hoes, push hoes and hand-weeding are still used when rouging of an individual plant or patch of weed is the most effective way of preventing the weed from spreading. Hand-weeding may also be used after mechanical inter-row weeding to deal with weeds left in the crop row. The hoe-ridger is specifically designed to achieve intra-row control in sugar beet, Thistle-bars are simple blades used to undercut perennial weeds with minimal soil disturbance. The brush weeder, or brush hoe, is used primarily for inter-row weeding of vegetable crop. 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 aim of this study was to determine the effects of conventional method of weed control on the quality, yield and plant height of potato crop with the following objective:

To find out the optimum time of application of hand weeding to control weeds

2. MATERIALS AND METHODS

The present investigation was conducted at the Research Farm of the Department of Vegetable Science, CCS Haryana Agriculture University, Hisar, during Rabi season of 2013-14. It is located at 29° 10' latitude north and 75° 46' longitude east with an elevation of 215.2 m above mean sea level. The experiment was laid out in randomized block design. The net plot size was 3.6 m x 3.6 m and potato tuber were planted at 60 cm x 20 cm spacing in last week of October. The study was laid out with five treatments (T_1- Hand weeding at 30 DAP and weed free later, T_{2-} Hand weeding at 40 DAP and weed free later, T_{3-} Hand weeding at 50 DAP and weed free later, T_{4-} Weed free, T_{5-} Weedy check) in randomized block design and replicated thrice. The number of weeds per meter square, NPK removal by weeds, potato tuber and haulm, plant height, tuber yield recorded.

2.1 Name and Number of Weeds

During the experiment two types of weeds were observed (monocot and dicot weeds). Both monocot weeds (Weeds in which shoot and root both are raised from single cotyledon) and dicot weeds were separately collected with the help of 1m square quadrant.

2.2 Nutrient Uptake by Weeds

Nutrient contents in weeds were extracted by most efficient methods (Nitrogen- Alkaline potassium permanganate method, Phosphorous- Olsen's method and Potassium- Flame photometer method). Then nutrient (Nitrogen, Phosphorus and Potassium) uptake by weeds was calculated by multiplying the nutrient contents in weeds with oven dry weight of weeds and dividing by hundred and expressed as kg /ha.

Nutrients uptake by weeds (kg/ha) =

$$\frac{[\text{Nutrient contents in weeds (\%)}] \times \text{Dry weight of weed (kg/ha)}}{100}$$

Nutrient contents =Nitrogen (N), phosphorus (P) and potassium (K) present in potato haulm

Nutrient content (%) = Concentration of N/P/K × Dilution factor

2.3 Nutrient Uptake by Potato Haulm

Nutrient (Nitrogen, Phosphorus and Potassium) uptake by haulm was calculated by multiplying the nutrient contents in leaves with oven dry weight of weeds and dividing by hundred and expressed as kg /ha.

Nutrients uptake by haulm (kg/ha) =

$$\frac{[\text{Nutrient contents in haulm (\%)}] \times \text{Dry weight of haulm (kg/ha)}}{100}$$

Nutrient contents =Nitrogen (N), phosphorus (P) and potassium (K) present in potato haulm

Nutrient content (%) = Concentration of N/P/K × Dilution factor

3. RESULTS AND DISCUSSION

3.1 Name and Number of Weeds

During experiment, two types of weeds were observed at experimental field (monocot and dicot weeds). Data recorded on number of weeds have been presented in Tables 1 & 2. Among monocot *Cyperus rotundus* L., *Asphodelus tenuifolius* Cav. and *Rumex* spp., whereas, *Fumaria parviflora* Lam.

Chenopodium album L., *Convolvulus arvensis*, *Melilotus alba* and *Amaranthus* spp. among dicot were most prominent weeds. Similar results were observed [9-13]. Among different species of weeds, *Fumaria parviflora* Lam. observed with maximum number followed by *Chenopodium album* L. [14]. Maximum number of *Fumaria parviflora* Lam. (92.3/m^2) was followed by *Asphodelus tenuifolius* Cav. (11.7/m^2) in weedy check treatment.

3.2 Nutrient Uptake by Weed

Data recorded on nutrient uptake by weed have been depicted in Table 3. Weed control treatments were also effect the nutrient uptake by weed. Significantly minimum nitrogen, phosphorus and potassium uptake by weeds was recorded with weed free treatment followed by hand weeding at 30 DAP and weed free later. However, significantly maximum N, P and K uptake by weed (172.1 kg/ha, 20.5 kg/ha and 171.7 kg/ha, respectively) was recorded with weedy check. These results are conformity with the results observed by [2,11,15].

3.3 Nutrient Uptake by Haulm

Significantly maximum nitrogen, phosphorus and potassium (177.2 kg/ha, 19.0 kg/ha and 198.3 kg/ha, respectively) uptake by haulm was recorded with weed free treatment followed by hand weeding at 30 DAP and weed free later (78.5 kg/ha, 6.3 kg/ha and 92.5 kg/ha, respectively). However, significantly minimum N, P and K uptake by haulm (23.3 kg/ha, 1.7 kg/ha and 32.3 kg/ha, respectively) was recorded with weedy check. Data pertaining to nitrogen up take by potato haulm as given in Table 4. These results are conformity with Singh et al. [11], Pramanick et al. [2] and Kumar et al. [15].

3.4 Nutrient Uptake by Potato Tuber

Data pertaining to nitrogen up take by potato tuber as given in Table 5. Weed control treatments were also effect the nutrient uptake by potato tuber. Significantly maximum nitrogen, phosphorus and potassium uptake (117.4 kg/ha, 16.1 kg/ha and 119.6 kg/ha, respectively) by potato tuber was recorded with weed free treatment followed by hand weeding at 30 DAP and weed free later. However, significantly minimum N, P and K uptake by potato tuber (12.3 kg/ha, 0.2 kg/ha and 15.9 kg/ha, respectively) was recorded with weedy check. These results are conformity with [1-4,10,11,15].

3.5 Plant Height

Maximum plant height at 30, 40, 50 and 100 days after planting was recorded in weed free i.e. 32.5 cm, 36.0 cm, 43.3 cm and 59.8 cm respectively followed by hand weeding at 30 DAP and weed free later (22.9 cm, 28.0 cm, 33.4 cm and 51.3 cm, respectively). Minimum plant height at 30, 40, 50 and 100 days after planting was recorded in weedy check i.e. 17.5 cm, 21.4 cm, 27.9 cm and 45.7 cm respectively (Table 6). Similar results have been observed by [4,8,9,16].

3.6 Tuber Yield (q/ha)

Highest total tuber yield (425.8 q/ha) was recorded under weed free treatment closely followed by hand weeding at 30 DAP and weed free later (234.2 q/ha). Significantly minimum tuber yield was recorded under weedy check treatment (131.7 q/ha) where weeds were allowed to grow throughout the growing season (Table 7). Reduction in tuber yield due to weeding at later stages of crop growth has earlier been reported by [2,10,11,15,17].

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

Treatments /herbicides (g/ha)	Number of dicot weeds / sq. m.					
	***Fumaria parviflora* Lam.**	***Chenopodium album* L.**	***Convovulus arvensis***	***Melilotus alba***	***Amaranthus* spp.**	**Total**
H.W.at 30 DAP* and weed free later	19.0(4.4)	10.0 (3.3)	2.3 (1.8)	4.3 (2.3)	1.3 (1.5)	37.0(6.1)
H.W. at 40 DAP* and weed free later	21.6(4.8)	9.3 (3.2)	5.3 (2.5)	1.0 (1.4)	1.0 (1.4)	38.2(6.2)
H.W. at 50 DAP* and weed free later	27.0(5.3)	19.6 (4.5)	7.3 (2.9)	3.0 (2.0)	3.0 (2.0)	60.0(7.8)
Weed free	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0(1.0)
Weedy check	92.3(9.7)	29.0(5.5)	15.3(4.0)	5.0(2.4)	5.0(2.4)	147.6(12.2)
C.D. at 5%	NS	NS	NS	NS	NS	2.9

DAP- Days after planting, NS- non significant, sq.m.- square meter, g/ha – gram per hectare, the values given in the parentheses are square root (x+1) transformed values

Table 2. Effect of weed control treatments on number of monocot weeds

Treatments /herbicides (g/ha)	Number of monocot weeds / sq. m.			
	***Cyperus rotundus* L.**	***Asphodelus tenuifolius* Cav.**	***Rumex* spp.**	**Total**
Hand weeding at 30 DAP* and weed free later	22.6 (4.9)	2.0 (1.7)	0.0 (1.0)	24.6 (5.1)
Hand weeding at 40 DAP* and weed free later	24.0 (5.0)	3.3 (2.1)	0.0 (1.0)	27.3 (5.3)
Hand weeding at 50 DAP* and weed free later	26.3 (5.2)	4.3 (2.3)	2.0 (1.7)	32.6 (5.8)
Weed free	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)	0.0 (1.0)
Weedy check	25.0 (5.1)	11.7 (3.6)	5.0 (2.4)	41.6 (6.5)
C.D. at 5%	NS	NS	NS	3.0

DAP- Days after planting, NS- non significant, sq.m.- square meter, g/ha – gram per hectare, the values given in the parentheses are square root (x+1) transformed values

Table 3. Effect of weed control treatments on nutrients uptake by weeds

Treatments/ herbicides (g/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
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)
C.D. at 5%	2.6	0.9	2.5

DAP- Days after planting, N-Nitrogen, P-Phosphorus, K= Potassium, g/ha –gram per hectare, kg/ha –kilo gram per hectare, CD- Critical difference, The values given in the parentheses are square root (x+1) transformed values

Table 4. Effect of weed control treatments on nutrients uptake by potato haulm

Treatments / herbicides (g/ha)	Dry weight of haulm (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Hand weeding at 30 (DAP)* and weed free later	1.9	78.5	6.3	92.5
Hand weeding at 40 (DAP)* and weed free later	1.8	71.9	5.4	84.6
Hand weeding at 50 (DAP)* and weed free later	1.6	66.5	4.7	77.8
Weed free	3.6	177.2	19.0	198.3
Weedy check	0.7	23.3	1.7	32.3
C.D. at 5%	0.4	14.2	3.5	17.6

DAP- Days after planting, N-Nitrogen, P-Phosphorus, K= Potassium, g/ha –gram per hectare, kg/ha –kilo gram per hectare, CD- Critical difference, The values given in the parentheses are square root (x+1) transformed values

Table 5. Effect of weed control treatments on nutrients uptake by potato tuber

Treatments / herbicides (g/ha)	Dry weight of tuber (t/ha)	N (kg/ha)	P (kg/ha)	K (kg/ha)
Hand weeding at 30 (DAP)* and weed free later	3.9	50.6	3.9	51.8
Hand weeding at 40 (DAP)* and weed free later	3.7	46.0	2.6	47.1
Hand weeding at 50 (DAP)* and weed free later	3.5	24.4	2.1	43.6
Weed free	7.3	117.4	16.1	119.6
Weedy check	2.1	12.3	0.2	15.9
C.D. at 5%	0.5	12.7	2.5	9.3

DAP- Days after planting, N-Nitrogen, P-Phosphorus, K= Potassium, g/ha –gram per hectare, kg/ha –kilo gram per hectare, tonnes per hectare, CD- Critical difference, The values given in the parentheses are square root (x+1) transformed values

Table 6. Effect of weed control treatments on plant height

Treatments/ herbicides (g/ha)	Plant height (cm)			
	30 DAP	40 DAP	50 DAP	100 DAP
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
C.D. at 5%	3.9	2.8	4.7	5.5

DAP- Days after planting, cm- centimeter, CD-critical difference

Table 7. Effect of weed control treatments on tuber yield

Treatments/ herbicides (g/ha)	Time of application	Tuber yield (q/ha)
Hand weeding and weed free later	30 (DAP)*	234.2
Hand weeding and weed free later	40 (DAP)*	223.0
Hand weeding and weed free later	50 (DAP)*	212.9
Weed free	-	425.8
Weedy check	-	131.7
C.D. at 5%	-	49.1

DAP – Days after planting, q/ha- quintal per hectare, CD-critical difference

4. CONCLUSION

Results revealed that if we do not allow weed to grow throughout the crop period than it will give better yield as compared to hand weeding done at later stage. So that's why where weed were allowed throughout the growing season gave minimum yield of potato tuber among all the treatments. Hand weeding at 30 days after planting found better than 40 and 50 DAP (Days after planting). It showed that if weeding is done before the crop-weed competition 4-6 weeks, it will be more effective because during this period weeds do not have much capacity to compete for nutrients, water, space and other essential component required for growth and development of plants.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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