Indian Journal of Weed Science **51**(4): 385–389, 2019

Print ISSN 0253-8040 Online ISSN 0974-8164

Effect of herbicides on weed control and potato tuber yield under different tuber eye orientations

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Article information

DOI: 10.5958/0974-8164.2019.00080.7

Type of article: Research article

Received : 4 August 2019
Revised : 24 October 2019
Accepted : 28 October 2019

Key words
Cut tuber

Herbicides

Sprout-eye

Weeds

Whole tuber

ABSTRACT

Weed management and planting methods in potato cultivation affect the tuber yield and quality significantly, and hence, requires proper management. Therefore, to explore the possibilities of developing a pre-emergence (PE) herbicide application system for potato planter specially for cut seed pieces (tubers) a study was conducted at ICAR-Directorate of Weed Research (DWR) during *Rabi* season of 2017-18 and 2018-19. The study includes different sprout-eye orientation of the potato tubers along with different weed management practices. The application of metribuzin at 0.75 kg/ha as PE effectively controlled the weeds and obtained a weed density of 2.43 and 2.04 weeds/m^2 and weed dry biomass of 1.35 and 1.64 g/m^2 respectively at 25 and 55 DAP. By application of the metribuzin as PE and paraquat as early-post emergence (PoE), the tuber yield was increased from 9-16.5%. The sprout-eye orientation has significant effect on tuber yield. The tuber yield was reduced by 28.3% and 16.7% respectively, in 270^0 sprout-eye orientation and random dropping over sprout-eye orientation of 90 ± 30^0. The highest tuber yield of 28.4 t/ha was obtained in planting of whole tuber having the size of 40 to 50 g per tuber. The application of metribuzin as PE effectively controlled the weeds, thus a PE applicator system can be developed along with the potato planter.

INTRODUCTION

Potato (*Solanum tuberosum L.)* is a most important food crop in the world and India ranks second in production of 51.3 million tonnes (Anonymous 2018). Indo-Gangetic Plains comprising of Uttar Pradesh, West Bengal, Bihar, Punjab and Haryana produces 80% of the total potato (Anonymous 2006). The production process of the potatoes is mainly depends on cultivation and weed management practices. The wider row spacing, frequent irrigations, use of manures and fertilizers favour the environment to early appearances of the weeds before germination of the tubers, and causes the tuber yield loss by 40-65% or even more in some cases (Singh *et al.* 2002). Thus, an effective weed management is required to reduce the tuber yield loss. The traditional manual and mechanical weed management involves human drudgery and becomes costlier compared to chemical weed management (Chethan and Krishnan 2017, Chethan *et al.* 2018a, Kumar *et al.* 2019). Different weed management practices have followed in potato cultivation; however the chemical management of the weeds has become popular because of its ease, economic and effective control of the weeds (Tomar *et al.* 2008, Kaur *et al.* 2016, Chethan *et al.* 2018b&c).

At present application of herbicides and planting of potatoes are done separately as two different operations. The effective control of weeds in potato cultivation by pre-emergence (PE) herbicides gives a possibility to develop a PE applicator along with the planter. Thus, labor required to apply PE herbicides and cost of potato cultivation may be get reduced. Therefore, a study has been conducted at ICAR – Directorate of Weed Research (DWR), Jabalpur to explore the possibilities to develop PE herbicide application system for potato planter especially developed for potato cut seed pieces.

MATERIALS AND METHODS

The experiment was conducted during the *Rabi* season of 2017-18 and 2018-19 at the research farm of ICAR-DWR, Jabalpur (23°13'57.3"N 79°58'14.4"E). The study site comes under the subtropical region with average rainfall of 1386 mm and evaporation of 1502mm.Soil properties of the study site had low organic carbon with clay loam texture having pH of 7.6 and bulk density of ~1.3 g/cm^2. The experiment was conducted in split plot design and replicated thrice.

The potato (v. *Kurfi Jyoti*) crop was cultivated with the three different weed management practices along with five different tuber sprout eye orientation treatments. The treatment was conducted in a plot having the dimensions of 6 × 7 m^2 area and the total area of potato crop cultivation was obtained by multiplying the number of treatments with treatment plot area. The weed management practices involved the application of metribuzin at 0.75 kg/ha as PE (Channappagoudar *et al.* 2007), paraquat at 0.5 kg/ha as early post-emergence (PoE) and control. The metribuzin was applied immediately after the planting of the potato tubers. Later, 4 hours of application of the metribuzin, a light irrigation for about two hours was provided through the sprinkler system. This treatment was conducted to simulate the condition which will be obtained during planting of potatoes by potato planter followed by irrigation and application of PE herbicides. In this condition, assumptions were made that, the metribuzin was applied along with the planter through PE application system. The paraquat was applied after five per cent germination of the planted tubers. The tubers germination was measured by placing a quadrant of size 2×5 m^2 randomly within the plot and then counting the germinated tubers. Two earthing-up operations, one at 25 days after planting (DAP) and another at 55 DAP (Sharma *et al.* 2012) was followed at all the treatments to support the potato plants and to ensure a proper soil environment for tuber growth and development. The control treatment does not involve any weed control activities except the recommended two earthing-up operations. The weed flora obtained within the treatment plots was measured by placing a quadrant of size 0.5×0.5 m^2 randomly over a field and recorded the data. The weed dry bio mass was estimated as per the standard procedure. The weed data was recorded at different intervals, such as at 25 and 55 DAP before earthing-up operations.

The potato tuber placement treatment involves the five different sprout-eye orientation of the tuber such as, 90±30^0, 0 or 180^0, 270^0, random drop and whole tuber. The whole tuber was cut longitudinally into two equal halves (Kabir *et al.* 2004, Hossain *et al.* 2011) and the size of the cut tubers varied from 25 to 30 gram per cut piece, whereas, whole tuber size varies from 40 to 50 gram per tuber. The random drop and the whole tuber was selected on the assumption that, the existing potato planters are planting the both cut and whole tubers, just by randomly dropping into the furrow. During dropping of the tubers randomly, the sprout-eye orientation was not maintained upward direction, and it was reported that due to random dropping yield reduction was the major issue (Sharma and Singh 2005). The tubers were planted on the ridges 60×20 cm spacing during *Rabi* season of 2017-18 and 2018-19. The tuber yield data was recorded by placing a quadrant of size 2×5 m^2 randomly within the plot at 120 DAP. The number of tubers obtained per unit area under different tubers was also recorded. Based on the performance of the treatments at field condition a PE applicator for potato planter specially developed for potato cut tubers will be developed.

RESULTS AND DISCUSSION

Effect on weeds

The treatment plots were heavily infested with *Medicago denticculata* followed by *Avena fatua, Rumex dentatus, Sonchus* sp., *Chenopodium ficifolium, Chenopodium album, Phalaris minor* and others. All the herbicides treatments significantly reduced the weed density and weed dry bio mass compared to the control treatments, where control treatments only contained two earthing-ups (Kaur *et al.* 2016). The earthing-up operation was followed in both tuber placement and weed management treatments to support the potato plant for tuber growth and as well as to control the weeds. After the application of herbicides as explained in materials and methods portion, the weed data was recorded at 25 DAP and 55 DAP of potato tubers *i.e.* before first and second earthing-up operations. Toxicity effect on the germinated tubers at initial stages in paraquat applied treatments was observed. At 25 DAP, it was observed that the highest weed density of 6.00 and 6.49 weeds/ m^2 was recorded in control plots followed by paraquat applied plots (4.25 and 4.34 weeds/m^2) and metribuzin applied plots during 2017-18 and 2018-19, respectively. Similarly the weed dry biomass was also the highest in the control plots (3.59 and 3.84 g/m^2) followed by paraquat and metribuzin applied plots during 2017-18 and 2018-19. The least weed density of 2.43 weeds/m^{2}and weed dry biomass of 1.35 g/m^2 (pooled values) were obtained in the plots where metribuzin was applied at 25 DAP. Thus, the application of metribuzin at 0.75 kg/ha was

effectively controlled the weeds. As like in 25 DAP, the similar type of results were also recorded at 55 DAP of potato tubers. However, it has seen that the first earthing-up operation followed in the treatments have controlled the weeds to some extent (**Table 1** and **2**). The highest weed density of 2.59 and 2.72 was recorded in the control treatments followed by paraquat and metribuzin applied treatments. The weed density values observed in the paraquat applied treatments was at par with control treatments. These values were differed from the metribuzin treatment because of the effective control of the weeds at germination level. This effect combined with the first earthing-up operation further lead to the significant control of the weeds. The same may be seen when it compared with the values obtained at 25 DAP. However, the case was not same when it was compared to the weed dry biomass obtained at 55 DAP. A significant difference in controlling the weeds was seen as the weed dry biomass obtained varied among the weed controlling treatments. A highest weed dry biomass of 4.56 and 5.03 g/m^2 was obtained in control treatments followed by paraquat (3.19 and 2.63 g/m^2) and metribuzin (1.61 and 1.67 g/m^2) applied treatments during 2017-18 and 2018-19, respectively. The effect of different weed management on weed control at 25 DAP and 55 DAP given seen in **Table 1** and **2**. Similarly, the effect of tuber placement on weed control can be seen in the tables. The similar type of results were also recorded by Mishra *et al.* (2002), Kaur *et al*. (2016). The tuber placement treatments, did not have any significant effect on weed control, however values obtained among the different tuber placement treatments varied due to the appearance of weed flushes in that particular plot. The findings were conforms with the findings of Singh *et al.* 2002, Mishra *et al.* 2002 and Tomar *et al.* 2008.

Effect on tuber yield

The tuber yield was significantly affected by both tuber placement (sprout-eye orientation) and weed management practices. Tuber yield was reduced significantly Practicing of recommended two earthing-up operations and obtained a very least tuber yield of 20.99 and 20.31 t/ha was recorded in control treatments during 2017-18 and 2018-19, respectively (**Table 3** and **Figure 1**). The pooled tuber yield for the treatments was 20.65 t/ha. But, by practicing the herbicide application, tuber yield was increased. It was seen that, 16.5 and 9% increase in tuber yield was obtained due to application of metribuzin and paraquat, respectively (**Figure 2**). Reduction in the tuber yield in paraquat treatments was due to its inefficacy to control the weeds effectively. The metribuzin was applied after planting of the tubers followed by sprinkler irrigation for two hours to create a situation as like in planting by the potato planter, controlled the weeds effectively. Thus, the application of metribuzin as PE was an effective weed control practice to increases the tuber yield. Therefore, an attachment for PE herbicide application in potato planter can be developed to reduce the weeding cost and time without compromising tuber yield.

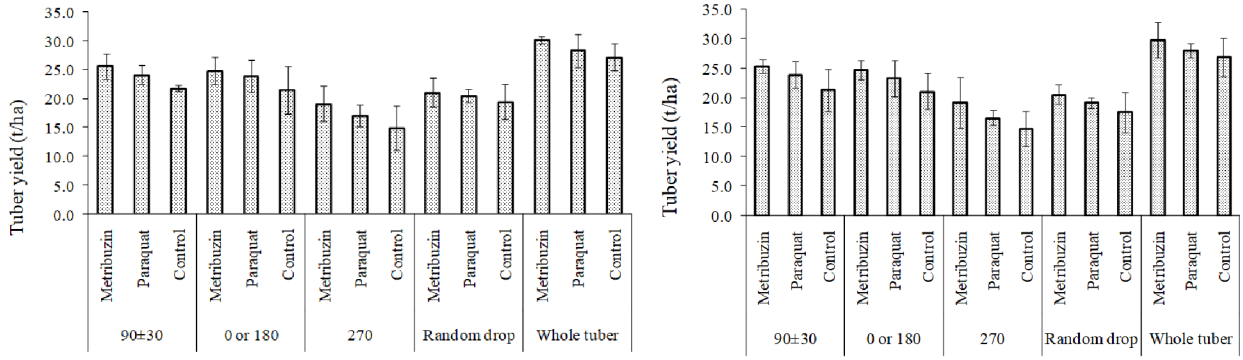
The significant effect of sprout-eye orientation on potato tuber drastically reduces the tuber yield, which can be seen in **Table 3**, **Figure 1** and **3**. Downward placing of the tuber sprout-eye (270^0) recorded a very least tuber yield of 17.07 and 16.87 t/ha followed by the random dropping (20.35 and 19.08 t/ha), horizontal placing *i.e.* 0 or 180^0 (23.45 and 23.03 t/ha) and upward placing *i.e.* 90±30^0 (23.85 and 23.50t/ha) during 2017-18 and 2018-19, respectively. The lower yields in the downward placing of the tubers were may be due to the late

Table 1. Effect of treatments on weed density

Treatment	25 DAP			55 DAP		
	2017-18	2018-19	Pooled value	2017-18	2018-19	Pooled value
Sprout eye orientation						
90^0 ± 30^0	4.14 (20.1)	4.22 (20.6)	4.18 (20.3)	2.21 (4.7)	2.33 (5.3)	2.28 (5.0)
0^0 or 180^0	4.22 (22.0)	4.47 (23.8)	4.35 (22.9)	2.66 (7.1)	2.81 (7.6)	2.76 (7.3)
270^0	4.33 (21.2)	4.51 (22.4)	4.43 (21.8)	2.22 (4.7)	2.35 (5.3)	2.29 (5.0)
Random dropping	4.05 (21.2)	4.39 (22.9)	4.25 (22.1)	2.44 (5.7)	2.41 (5.6)	2.43 (5.6)
Whole tuber	4.22 (18.6)	4.65 (24.2)	4.48 (21.4)	2.43 (5.6)	2.21 (4.8)	2.36 (5.2)
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
Metribuzin 3 DAP (PE.) *fb* earthing-up	2.32 (5.4)	2.51 (5.9)	2.43 (5.7)	2.04 (4.1)	1.97 (3.6)	2.04 (3.9)
Paraquat (PoE) 5% of crop emergence *fb* earthing-up	4.25 (18.6)	4.34 (19.2)	4.31 (18.9)	2.53 (6.1)	2.58 (6.4)	2.56 (6.3)
Control	6.00 (37.9)	6.49 (43.2)	6.27 (40.5)	2.59 (6.3)	2.72 (7.1)	2.67 (6.7)
LSD (p=0.05)	0.88	0.70	0.73	0.42	0.37	0.29

Weed data subjected to square root transformation ($\sqrt{(x+0.5)}$; original values are in parentheses

germination of tubers, poor growth, damage to sprout-eye and poor plant vigour. In random dropping of the tubers the probability of upward facing of the sprout-eye is very less and there will be maximum chances of getting the same results like in sprout-eye orientation at 270^0. There was 28.3% and 16.7% reduction in tuber yield for sprout-eye orientation at 270^0 and random dropping, respectively compared to the sprout-eye orientation at 90 ± 30^0. However, there was very little variation in tuber yield among the sprout-eye orientation at 90 ± 30^0 and 0 or 180^0 (**Figure 3**). It is might be because in both the treatments, sprout eye orientation was within the safer zone for healthier sprout development and plant vigour. The whole tuber treatment produced the highest tuber yield of 28.54 and 28.25 t/ha during 2017-18 and 2018-19, respectively even though it was dropped randomly from above the surface. It was mainly because that, the whole tuber contained the more number of sprout-eyes over it surface and



1.a Effect of treatments during 2017-18

1.b Effect of treatments during 2018-19

Figure 1. Effect of different treatment on potato tuber yield

Table 2. Effect of treatments on weed dry weight

Treatment	25 DAP			55 DAP		
	2017-18	2018-19	Pooled value	2017-18	2018-19	Pooled value
Sprout eye orientation						
90 ± 30^0	2.25(6.5)	2.39(7.5)	2.32(7.0)	2.25(5.3)	2.96(10.4)	2.66(7.8)
0 or 180^0	2.62(8.6)	2.78(9.8)	2.71(9.2)	3.12(13.0)	3.28(14.9)	3.20(14.0)
270^0	2.42(6.1)	2.58(7.0)	2.53(6.6)	2.78(9.6)	2.90(10.8)	2.85(10.2)
Random dropping	2.10(4.9)	2.23(5.6)	2.18(5.2)	3.01(9.4)	3.18(11.6)	3.14(10.5)
Whole tuber	2.37(5.6)	2.52(6.5)	2.48(6.1)	4.44(24.6)	3.24(13.4)	3.96(19.0)
LSD (p=0.05)	NS	NS	NS	NS	NS	NS
Weed management						
Metribuzin 3 DAP (PE) *fb* earthing-up	1.29(1.4)	1.35(1.6)	1.35(1.5)	1.61(2.3)	1.67(2.6)	1.64(2.5)
Paraquat (PoE) 5% of crop emergence *fb* earthing-up	2.17(4.7)	2.31(5.3)	2.25(5.0)	3.19(11.2)	2.63(6.9)	2.99(9.0)
Control	3.59(13.0)	3.84(14.9)	3.73(14.0)	4.56(23.6)	5.03(27.2)	4.86(25.4)
LSD (p=0.05)	0.41	0.42	0.32	0.71	0.87	0.73

Weed data subjected to square root transformation ($\sqrt{(x+0.5)}$; original values are in parentheses

Table 3. Effect of different treatments on potato tuber yield

Treatment	Year wise tuber yield (t/ha)		Pooled yield (t/ha)
	2017-18	2018-19	
Sprout eye orientation			
90 ± 30^0	23.85	23.50	23.68
0 or 180^0	23.45	23.03	23.24
270^0	17.07	16.87	16.97
Random dropping	20.35	19.08	19.72
Whole tuber	28.54	28.25	28.40
LSD (p=0.05)	3.07	5.92	3.52
Weed management			
Metribuzin @ 3 DAP (PE) *fb* earthing-up	24.17	23.93	24.05
Paraquat(PoE) @ 5% of crop emergence *fb* earthing-up	22.80	22.20	22.50
Control	20.99	20.31	20.65
LSD (p=0.05)	1.83	2.47	1.63

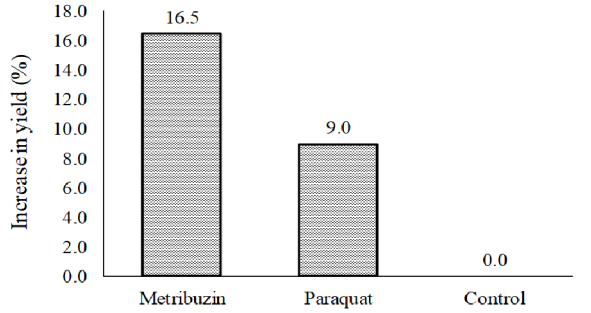


Figure 2. Percentage of increase in tuber yield due to weed management practices

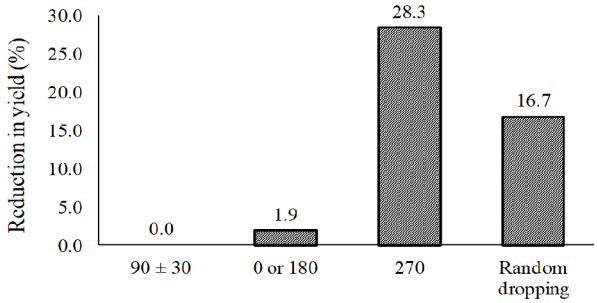


Figure 3. Percentage of reduction in tuber yield under different sprout-eye orientation

during dropping, one or the other sprout-eye might have orientated upward direction. More number of sprout-eyes helps more plant vigour and production of more number of tubers. The similar findings were also observed by Kabir *et al.* 2004 and Sharma and Singh 2005. The obtained results from the experiment showed that, application PE herbicide *i.e.* metribuzin effectively controls the weeds without compromising the tuber yield. Thus a PE applicator can be developed along with the planter for effective weed control.

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