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RESEARCH ARTICLE

Effect of planting geometry and potato seed tuber size on weeds and potato tuber yield

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ABSTRACT

A field experiment was conducted during winter *(Rabi)* seasons of 2014-15 and 2015-16 at Punjab Agricultural University, Ludhiana, India to study the effect of potato planting geometry (50 × 15 cm, 65 × 11.5 cm, 70 × 10.7 cm and 75 × 10 cm) and seed tuber size (25-35 mm, 35-45 mm, 45-55 mm) on weed density and biomass, and tuber yield of potato. The potato canopy cover was higher and the weed density and biomass were lower with closer planting geometry of 50 × 15 cm followed by 65 × 11.5 cm. The growth attributes (number of stems/plant and leaf area index), tuber number and tuber yield were not significantly influenced by varying planting geometry. Potato seed tuber size exerted a significant effect on weed infestation resulting in significantly lower weed density and biomass with large sized seed tubers followed by medium sized seed tubers as compared to small sized seed tubers. Growth attributes, tuber number and tuber yield of potato were also significantly higher with large sized seed tubers followed by medium sized tubers compared to small sized tubers. Thus, the potato planting geometry of 50 × 15 cm for manual planting by small and marginal farmers and 65 × 15 cm for mechanized potato production along with medium sized seed tubers are the viable options for effective weed management and optimal potato tuber yield.

Keywords: Planting geometry, Potato, Seed tuber size, Tuber yield, Weed management

INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important commercial vegetable crops widely grown in India and abroad. India is the second largest potato producer in the world with an area of 2.17 million ha and production of 50.2 million tons (FAOSTAT 2021). Among the several constraints in potato cultivation, weeds are the major ones which often pose a serious problem in its production (Yadav *et al.* 2021). Even though potato plants have quick spreading and robust growing nature yet, it is considered as a weak competitor of weeds. Weed management is a challenge for potato production program because of scarcity of labor for hand weeding and limited options for registered herbicides (Bhullar *et al.* 2015). Besides, wider row spacing in potato also favors heavy infestation of variety of weed species by providing favorable conditions for an early start of weeds well before the crop emergence. To achieve high tuber yield, weeds must be controlled at a proper stage, otherwise they reduce tuber yield by 34.4 to 86.0% (Monteiro *et al.* 2011 and Yadav *et al.* 2014), depending on weed growth and competitiveness. Potato producers usually apply early post-emergence herbicides followed by earthing up with tractor-drawn implements to suppress late emerging weeds. Weeds should be controlled in initial phases of crop growth by increasing crop competition through adoption of best crop production practices and making microenvironment conducive to potato crop. In this regard, planting geometry can play a vital role as growth and development of weeds can be suppressed by narrowing planting geometry (Mahajan *et al.* 2016). Closely spaced crop provides good smothering potential on growth and development of weeds due to less availability of space for growth and development, thereby competing for nutrients and moisture better than the weeds. Similarly, a crop's ability to suppress weeds can also be enhanced if crop achieves early vigorous growth. Potato seed tuber size can also play an important role in initial faster crop growth as large sized tubers have more availability of nutrients (stored food) to the plant which help in early emergence and establishment and thus, vigorous and faster growth of potato plants and having crop architecture and microenvironment that smothers weeds. The weeds emerging out under better crop

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canopy are generally frail and do not have severe negative effect on tuber productivity. Thus, the present study was undertaken to quantify the influence of potato planting geometry and seed tuber size on weed infestation and productivity of potato crop.

MATERIALS AND METHODS

A field experiment was carried out during winter (*Rabi*) seasons of 2014-15 and 2015-16 at Punjab Agricultural University, Ludhiana, India representing the Indo-Gangetic alluvial plains. The soil (0-15 cm) was loamy sand with neutral pH (7.20), normal electrical conductivity (0.24 mmhos/cm), medium organic carbon (0.60%), low available N (260 kg/ha), and high available P (42.1 kg/ha) and K (400 kg/ha). The experiment was conducted in split plot design with three replications. The main plots consisted of four planting geometries: 50 × 15 cm, 65 × 11.5 cm, 70 × 10.7 cm and 75 × 10 cm, and sub plots three seed sizes (based on diameter): small (25-35 mm), medium (35-45 mm) and large (45-55 mm). Plant population was uniform in all the planting geometries. The sowing of potato cultivar '*Kufri Pukhraj*' was done on 17 October during 2014-15 and 19 October during 2015-16. The seed rate for small, medium and large seed tuber grades was 3.3, 6.0 and 9.3 tons/ha, respectively. The first irrigation was given immediately after sowing to ensure better germination. While irrigating the field, over flooding of the ridges was avoided to prevent subsequent hardening of the soil surface which interferes with emergence, growth, and development of tubers. The crop received 5 and 6 irrigations during first and second year, respectively. Application of paraquat 0.30 g/ha was done at 5% emergence of the potato crop after 10 days of sowing (DAS). Earthing up was done manually at 30 DAS to enhance proper tuberization and weed control. Haulm cutting was done in the first week of January and the crop was harvested in end January. Weed density (grasses, broad-leaved weeds and sedges) was recorded before herbicide application (10 DAS), before earthing up (30 DAS) and after earthing up (45 DAS) while total weed biomass was recorded before earthing up (30 DAS) and after earthing up (45 DAS). Leaf area index (LAI), number of stems/plant and canopy cover (%) were recorded at 30 and 45 DAS. Haulm yields were recorded at haulm cutting stage while the tuber yields and tuber number were recorded at harvesting. The pooled data were subjected to statistical analysis using OPSTAT software (http://14.139.232.166/opstat) developed by CCS Haryana Agricultural University, Hisar (Haryana), India.

RESULTS AND DISCUSSION

Weed flora

The weed flora consisted of *Poa annua* L., *Phalaris minor* Retz., *Cyperus rotundus* L., *Rumex dentatus* L., *Chenopodium album* L., *Malva parviflora* L., *Medicago denticulata* Willd., *Anagallis arvensis* L. and *Coronopus didymus* L.. Similar weed flora in potato was reported by Bhullar *et al.* (2015).

Effect of planting geometry on weeds

The total and species wise density of grasses, sedges, broad-leaved weeds were significantly influenced by planting geometry (**Table 1**). The lowest weed density at 10, 30 and 45 DAS was observed with closer planting geometry (50 × 15 cm) and it was significantly lower than wider planting geometries of 65 × 11.5 cm, 70 × 10.7 cm and 75 × 10 cm. Among the wider planting geometries (65 × 11.5 cm, 70 × 10.7 cm and 75 × 10 cm), the planting geometry 65 × 11.5 cm recorded significantly lower individual as well as total weed density, and the planting geometry 75 × 10 cm recorded the highest weed density at all the growth stages. Similar trend was observed for weed biomass at 30 and 45 DAS. Lower weed density at initial phase of crop (10 DAS) with closer plant geometries of 50 × 15 cm and 65 × 11.5 cm was due to narrow inter-row spacing in these planting geometries as most of the weeds emerged in the furrows but not on the ridges. At the later stages of crop growth i.e. 30 and 45 DAS, the lower weed density and biomass in planting geometries of 50 × 15 cm and 65 × 11.5 cm was mainly due to the higher canopy cover of the crop (**Table 2**) which might have enhanced smothering potential and thus, the competitive ability of the crop. The benefits of reducing row spacing has also been reported earlier in relation to early canopy closure that increases the capability of crops to compete with weeds for sunlight, nutrients and water (Laurie *et al.* 2015) and lowering weed density and biomass (Hussain *et al.* 2016, Kalaichelvi 2008).

Effect of planting geometry on crop growth and tuber yield

The number of stems per plant and LAI at 30 and 45 DAS, tuber yield, tuber number and haulm yield were not affected significantly with planting geometry (**Table 1** and **2**) and that might be due to uniform plant population (13.3 plants/m^2) in all the planting geometries. Further, the number of stems per plant apart from being a varietal character also depends upon seed tuber size and their physiological status, hence, it was not influenced as the cultivar and seed size were uniform in all the planting geometries. Earlier studies have also reported non-significant effect of planting geometries on number of stems per plant (Akassa *et al*. 2014, Dagne 2015 and Kumar *et al*. 2012) and tuber yield (Singh *et al*. 1995, Kumar *et al*. 2001, Kumar 2012 and Kumar *et al.* 2021). However, canopy cover was significantly influenced by planting geometries (**Table 2**), the significantly highest being in closer planting geometry (50 × 15 cm). Among the wider planting geometries (65 × 11.5 cm, 70 × 10.7 cm and 75 × 10 cm), 65 × 11.5 cm recorded significantly higher canopy cover than 75 × 10 cm. Laurie *et al.* (2015) also observed that canopy cover for the narrow planting geometry was faster than that of wider planting geometry.

Effect of seed tuber size on weeds

The seed tuber size had non-significant effect on weed density and weed biomass at 10 DAS (**Table 1**). However, at 30 and 45 DAS, the weed density was significantly influenced by seed tuber size. The significantly lowest weed density was observed with large sized seed tubers than medium and small sized tubers. The medium sized tubers had also significantly lower weed population than small sized tubers. The similar results were observed for total weed biomass at 30 and 45 DAS. The effect of seed tuber size on weed infestation might be due to higher number of stems per plant, LAI and canopy cover (**Table 2**) with medium and large seed tubers. The higher availability of nutrients (stored food) to the plants in large tubers results early emergence and establishment, and thus, more growth and development of plants. This faster canopy closure and vigorous growth helped the crop to be more competitive as compared to the associated weeds.

Effect of potato seed tuber size on crop growth and tuber yield

Potato seed tuber size had a significant influence on number of stems per plant, canopy cover and LAI at 30 and 45 DAS (**Table 2**). All these parameters were significantly higher with large sized seed tubers as compared to medium and small sized seed tubers, the medium sized seed tubers further being better than small sized seed tubers. The higher number of stems per plant with large and medium sized seed tubers might be due to higher number of eyes/tuber which consequently produced higher number of stems per plant (Kumar *et al.* 2015). The higher LAI and canopy cover with large seed tubers might be due to the more availability of nutrients (stored food) to the plant resulting in early emergence and establishment and thus, more growth and development of plants. Nasir and Akassa (2018), Ebrahim *et al.* (2018) and Kumar *et al.* (2021) also reported higher number of stems per plant and LAI with large sized seed tubers.

The significantly highest number of potato tubers was obtained with large sized potato seed tubers than all the other grades of seed tubers (**Table 2**). The medium sized seed tubers had also significantly higher number of tubers than small sized seed tubers. The higher number of tubers per unit area with large and medium sized seed tubers might be due to higher number of eyes on large sized seed tubers which consequently produced higher number of stems per plant and ultimately the higher number of tubers per plant (Kumar *et al.* 2015). Nasir and Akassa (2018), Ebrahim *et al.* (2018) and Kumar *et al.* (2021) also reported higher number of stems and tubers per plant with large sized seed tubers. The highest tuber and haulm yield (42.9 and 17.9 t/ha,

Table 1. Potato planting geometry and seed size effects on weed density and biomass in potato

Treatment	Weed density (no./m^2)												Weed biomass (g/m^2)	
	Before herbicide application (10 DAS)				Before earthing-up (30 DAS)				After earthing-up (45 DAS)				Before earthing-up (30 DAS)	After earthing-up (45 DAS)
	BLW	Grasses	Sedges	Total	BLW	Grasses	Sedges	Total	BLW	Grasses	Sedges	Total		
Planting geometry (cm × cm)														
50 × 15	43.4	61.9	10.6	115.9	37.3	9.8	5.1	52.2	4.6	3.3	2.1	10.0	5.4	2.1
65 × 11.5	71.2	118.2	17.0	206.4	50.8	18.2	6.9	75.9	6.0	5.6	3.1	14.7	12.4	4.9
70 × 10.7	81.0	128.9	19.7	229.6	54.5	22.4	8.2b	85.2	6.9	6.4	4.3	17.7	14.2	6.5
75 × 10	88.2	140.4	23.0	251.7	58.3	26.9	9.6	94.8	8.2	6.8	4.9	19.9	16.0	7.9
LSD (p=0.05)	7.9	11.2	2.3	15.7	6.0	3.7	1.7	6.9	1.5	0.8	0.8	1.8	2.7	1.1
Potato seed size (mm)														
25-35	69.5	111.3	17.5	198.3	58.5	24.5	9.8	92.8	9.1	6.8	4.6	20.4	15.5	6.4
35-45	72.3	111.7	17.8	201.8	50.7	18.8	7.5	77.0	6.3	5.5	3.5	15.3	11.9	5.3
45-55	71.2	114.1	17.3	202.6	41.5	14.7	5.1	61.3	3.9	4.3	2.8	11.0	8.7	4.3
LSD (p=0.05)	NS	NS	NS	NS	4.6	2.4	1.3	6.1	1.3	1.0	0.8	1.4	1.1	0.4

Pooled data over 2 years; DAS = days after sowing; BLW= broad-leaved weeds

Table 2. Planting geometry and potato seed size effects on growth parameters and tuber yield of potato

Treatment	No. of stems/plant		Canopy cover (%)		LAI		Tuber number ('000/ ha)	Tuber yield (t/ha)			Haulm yield (t/ha)		
	Before earthing-up (30 DAS)	After earthing-up (45 DAS)	Before earthing-up (30 DAS)	After earthing-up (45 DAS)	Before earthing-up (30 DAS)	After earthing -up (45 DAS)		2014 -15	2015-16	Pooled	2014 -15	2015 -16	pooled
Planting geometry (cm × cm)													
50 × 15	3.14	3.33	60.6	94.6	2.09	2.76	940.2	41.3	42.3	41.8	16.6	16.3	16.5
65 × 11.5	3.31	3.67	53.8	87.8	2.04	2.64	918.4	41.6	41.7	41.7	16.1	16.4	16.3
70 × 10.7	3.69	3.78	51.2	83.9	1.99	2.70	940.4	42.1	41.9	42.0	16.4	16.1	16.3
75 × 10	3.42	3.50	48.3	80.8	2.01	2.56	899.7	41.2	40.5	40.8	17.0	16.2	16.6
LSD (p=0.05)	NS	NS	4.97	5.13	NS	NS	NS	NS	NS	NS	NS	NS	NS
Seed size (mm)													
25-35	2.63	2.79	46.4	83.2	1.68	2.27	836.1	39.3	39.1	39.2	14.9	14.6	14.7
35-45	3.46	3.67	52.5	86.7	2.15	2.78	953.9	42.4	42.8	42.6	16.7	16.5	16.6
45-55	4.08	4.25	61.6	90.4	2.26	2.95	984.0	42.9	42.9	42.9	18.1	17.7	17.9
LSD (p=0.05)	0.43	0.35	2.63	2.12	0.14	0.16	23.6	1.5	1.3	0.9	2.0	1.9	1.3

Pooled data over 2 years; DAS = days after sowing; LAI = leaf area index

Table 3. Correlation among potato growth attributes, weed density and biomass, and potato tuber yield

Treatment	LAI		Stems (no./plant)		Canopy cover (%)		Weed density (no./m^2)			Weed biomass (g/m^2)	
	30 DAS	45 DAS	30 DAS	45 DAS	30 DAS	45 DAS	10 DAS	30 DAS	45 DAS	30 DAS	45 DAS
LAI (45 DAS)	0.946^{**}										
Stem no./plant (30 DAS)	0.823^{**}	0.880^{**}									
Stem no./plant (45 DAS)	0.799^{**}	0.851^{**}	0.946^{**}								
Canopy cover (%) (30 DAS)	0.748^{**}	0.818^{**}	0.588^{*}	0.631^{*}							
Canopy cover (%) (45 DAS)	0.563^{NS}	0.639^{*}	0.284^{NS}	0.293^{NS}	0.882^{**}						
Weed density (no./m^2) (10 DAS)	-0.100^{NS}	-0.156^{NS}	0.276^{NS}	0.219^{NS}	-0.557^{NS}	-0.815^{**}					
Weed density (no./m^2) (30 DAS)	-0.652^{*}	-0.739^{**}	-0.418^{NS}	-0.437^{NS}	-0.935^{**}	-0.978^{**}	0.733^{**}				
Weed density (no./m^2) (45 DAS)	-0.727^{*}	-0.814^{*}	-0.525^{NS}	-0.530^{NS}	-0.954^{**}	-0.956^{**}	0.635^{**}	0.981^{**}			
Weed biomass (g/m^2) (30 DAS)	-0.590^{*}	-0.688^{*}	-0.339^{NS}	-0.348^{NS}	-0.922^{**}	-0.970^{**}	0.790^{**}	0.977^{**}	0.960^{**}		
Weed biomass (g/m^2) (45 DAS)	-0.464^{NS}	-0.531^{NS}	-0.137^{NS}	-0.178^{NS}	-0.826^{**}	-0.984^{**}	0.891^{**}	0.946^{**}	0.902^{**}	0.945^{**}	
Potato tuber yield (t/ha)	0.922^{**}	0.960^{**}	0.841^{**}	0.870^{**}	0.731^{**}	0.531^{NS}	-0.083^{NS}	-0.630^{*}	-0.718^{*}	-0.578^{*}	-0.444^{NS}

*Significant at p= 0.05 level; **Significant at p = 0.01 level; NS = non-significant; LAI = leaf area index; DAS = days after seeding

respectively) were obatined with the large seed tubers and it was statistically at par with the medium seed tubers (42.6 and 16.6 t/ha, respectively) but significantly higher than that with small tubers. The medium seed tubers also recorded significantly higher tuber and haulm yield than small seed tubers. Increase in tuber and haulm yield with medium and large seed tubers might be due to increase in number of tubers and stems per plant. Ebrahim *et al.* (2018) also reported higher total tuber yield with medium to large sizes.

Correlation among growth attributes, weed infestation and tuber yield

LAI at 30 and 45 DAS was significantly and positively correlated with number of stems per plant and canopy cover except LAI at 30 DAS which exhibited a positive but non-significant correlation with canopy cover at 45 DAS (**Table 3**). LAI at 30 and 45 DAS had significant negative correlation with weed density at 30 and 45 DAS and with weed biomass at 30 DAS; whereas it had negative but non-significant correlation with weed biomass at 45 DAS. The number of stems per plant at 30 and 45 DAS had a significant and positive correlation with canopy cover at 30 DAS, however, it had positive but non-significant correlation with canopy cover at 45 DAS. Canopy cover at both the stages exhibited a significant negative correlation with weed density and weed biomass. Weed density at 30 and 45 DAS had a highly significant and positive correlation with each other and with weed biomass at both the stages. Similarly, weed density at 10 DAS had also significant and positive correlation with weed density and biomass at 30 and 45 DAS. Potato tuber yield showed a significant positive correlation with potato LAI and number of stems per plant at 30 and 45 DAS and with canopy cover at 30 DAS. However, potato tuber yield showed a significant negative correlation with weed density at 30 and 45 DAS and weed biomass at 30 DAS.

Conclusion

The closer planting geometry in combination with medium potato seed size tubers can be used for better weed management and higher potato tuber yields. Thus, the potato planting geometry of 50 × 15 cm for manual planting by small farmers and 65 × 15 cm for mechanized potato production along with medium sized potato seed tubers (35-45mm) may be used as a viable component of integrated weed management for higher potato productivity.

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