



Influence of haulm killing date and variety on production of seed size tubers in potato (*Solanum tuberosum*)

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ABSTRACT

Potato (*Solanum tuberosum* L.) varieties, viz. Kufri Lauvkar (early maturing), Kufri Gaurav and Kufri Jyoti (medium maturing) were examined during the years 2018–19 and 2019–20 for the seed size tubers production with 3 dates of haulm killing, viz. 70, 80, and 90 days after planting under West-Central Indian conditions at ICAR-Central Potato Research Institute, Regional Station Gwalior, Madhya Pradesh. Haulm killing at 80 (15.05 t/ha) and 90 days (14.60 t/ha) noticed significantly greater seed size tubers weight over 70 days' haulm killing (12.13 t/ha). Kufri Gaurav recorded substantially greater number of seed size tuber (288 t/ha) and weight (15.76 t/ha) than the other two varieties. Eighty days haulm killing was observed to be the best seed significantly: non-seed ratio (1.088 by number and 0.659 by weight) followed by 70 days (1.140 by number and 0.734 by weight) over the poorest 90 days haulm killing (1.121 by number and 0.946 by weight). Therefore, for achieving high seed-size potato tubers, haulm cutting should be done at 80 DAP.

Keywords: Growth attributing parameters, Haulm killing, Health standards, Plant emergence, Seed size tubers, Varieties

Seed is the most expensive input in potato (*Solanum tuberosum* L.) production, accounting for 40–50% of total production costs (Kushwah and Singh 2011, Sadawarti *et al.* 2017), and it is also one of the most essential ingredients for the effective production of potato (Lacha *et al.* 2012). Standard seed tuber weighing 25–125 g is recommended as seed size tubers (IMSCS 2013). The size of the seed tuber has a significant impact on overall yield and graded or marketable tuber yields, hence it is important to consider it while determining the seed rate per unit area (Dagne *et al.* 2018). According to Kumar *et al.* (2009), Singh and Kushwah (2010) and Virtanen and Seppanen (2014), one of the factors employed in seed potato production is haulm/vine killing, which predominantly controls the profile of tuber size. Haulm killing is done to halt the tubers' growth to lower the size of seeds and to achieve consistent distribution of size with the highest percentage of tubers in the most lucrative size range and to decrease the chance of virus disease spreading by preventing plant to plant transmission by vectors like aphids (Kempenaar and Struik 2007). Where the growing season is small, one can

utilize haulm killing to expedite harvesting, get the right tuber size, fortify the skins of the tubers before harvest, and stop plant infections from spreading among crops and foliage (Struik and Wiersema 1999). More than 70% of the tubers are dispersed in the desired size according to the haulm killing method, which is popularly utilized on mature plants and is used to manage tuber size. Early haulm killing lowers crop output, whereas too-late haulm killing raises the infection risk and potato infections (Struik and Wiersema 1999). Removing the potato vines before harvest will enhance appearance of tuber, control tuber size and enhance tuber release of vine, making harvest procedure easier (Zotarelli *et al.* 2019). Interaction between date of haulm killing and variety maintained growth period which ultimately affects yield, tuber size distribution and quality. However, information regarding dehaulming on seed grade tuber yield and quality is scanty. Under such situations, the need was felt to develop optimum days of dehaulming and crop growth duration for the maximization of seed size tuber yield with quality and economical returns to seed producers. Considering the need for the production of seed size/good seed tubers as per IMSCS, the present study was carried out wherein early, and medium maturing varieties were used.

MATERIALS AND METHODS

The experiment was conducted during 2018–19 and 2019–20 at ICAR-Central Potato Research Institute,

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Regional Station, Gwalior, Madhya Pradesh. Three popular potato (*Solanum tuberosum* L.) varieties, Kufri Lauvkar (early maturing), Kufri Gaurav and Jyoti (both medium maturing) were examined for seed size tuber's production with 3 haulm killing dates, viz. 90, 80, and 70 DAP. During the final week of October 2018–19 and 1st week of November 2019–2020, well-sprouted tubers of seed size having 40 to 50 g weighing 60 cm (row to row) and 20 cm of spacing (plant to plant) has been planted. The factorial randomized block design (RBD) design has been used to set up the field experiment. Potassium, phosphorus, and nitrogen were applied at rates of 150, 80 and 100 kg/ha, respectively. According to standard seed plot techniques, the seed crop was grown.

RESULTS AND DISCUSSION

Plant emergence and growth attributing parameters:

Days to haulm killing did not show significant variation for final emergence and growth parameters, viz. stem number/plant, plant height and compound leaves/plant when recorded 45–50 days after planting. No significant difference was recorded in the number of stem and compound leaves/plant, plant height and vigour (scale 1–5) among 70 and 80 day's haulm killing dates in Kufri Khyati (Sadawarti *et al.* 2017) and in Kufri Pukhraj under seed potato production under Dharwad conditions of Karnataka (Kumar *et al.* 2009). This might be due to the fact that uniform-sized and healthy seed tubers were planted. Besides, more or less favourable soil temperature and moisture conditions have prevailed the same in all the plots. These results are in agreement with Alam *et al.* (2017).

Seed size tubers (25–125 g) are very important for use as seed tubers in the successive crop season (Sadawarti *et al.* 2019). Seed tubers were divided into three sizes: 25 g and >125 g (non-seed size), 25–125 g and >125 g to quantify total tubers for further seed multiplication in accordance with the minimum seed certification criteria of India (seed size). Haulm killing at different dates significantly ($P < 0.05$) affected the total tuber yield of different potato cultivars.

Non seed size tubers (<25 and >125 g): In comparison to Kufri Lauvkar (127 thousand/ha), Kufri Gaurav (302 t/ha)

and Kufri Jyoti (194 t/ha) recorded much higher values for the 25 g grade. Haulm killing (216 t/ha) at 80 days recorded a significantly higher tuber number over both 70 (203 t/ha) and 90 days of haulm killing (204 t/ha). In interaction, Kufri Gaurav, with 80 days haulm killing, recorded significantly highest <25 g tubers (315 t/ha) (Table 1). Variations in <25 g tubers/ha were reported in Kufri Chandramukhi (193 t/ha), Kufri Sindhuri (328 t/ha) and Kufri Chipsona-1 (208 t/ha) on November 7 planted and harvested at 80 days of haulm killing dates (Sadawarti *et al.* 2019). Similarly, Kufri Jyoti (2.01 t/ha) and Kufri Gaurav (3.50 t/ha) showed significantly greater tuber weight over Kufri Lauvkar (1.44 t/ha). The importance of tubers having small-size was at par with all haulm killings (Table 1). In interaction, Kufri Gaurav, with 70 days haulm killing (3.74 t/ha), recorded considerably more <25 g tubers than any other combinations. Similar outcomes were noted by Kumar *et al.* (2001) with a 10-days delay in haulm killing from 60–70 and 80 days. In comparison to 70 days haulm cut (38 thousand and 7.0 t/ha), 80 days haulm cut resulted in significantly bigger size tubers by weight and quantity (51 thousand and 9.6 t/ha, respectively) (Sadawarti *et al.* 2017). Even at an advanced crop stage, an early harvest results in considerable decreases in proportion of large tubers in seed crop (Mandal and Das 2020, Sadawarti *et al.* 2022) as well as in ware potato crop (Singh *et al.* 2022) and as well as tuber-specific gravity (Silva, 2004). This confirms that an early harvest results in more number of small size tubers and less number of large size tubers.

Seed-size tubers (25–125 g): Seed-size tubers are necessary for usage as seed tubers in the following crop season (Sadawarti *et al.* 2019). Significantly greater numbers (Table 1) were recorded with Kufri Gaurav (288 t/ha) and Kufri Jyoti (217 t/ha) than by Kufri Lauvkar (185 t/ha). The number of seed-sized tubers increased significantly as the haulm killing days went on and the highest and at par was recorded in 80 and 90 days haulm killing (238 t/ha). Only a small percentage of the tubers which are initiated during the first 4–6 weeks of growth eventually achieve commercial size (Sharkar *et al.* 2019). In comparison, Kufri Gaurav

Table 1 Effect of haulm killing and varieties on grade-wise seed tuber number (000/ha)

Variety/DOHK	Non seed size								Seed size				Total			
	<25 g				>125 g				25–125 g							
	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean
Kufri Lauvkar	117	132	131	127	63	58	63	61	154	207	194	185	334	397	388	373
Kufri Jyoti	187	200	195	194	28	31	57	39	201	221	229	217	417	453	480	450
Kufri Gaurav	305	315	287	302	30	54	83	56	285	285	293	288	620	654	663	646
Mean	203	216	204		40	48	68		214	238	238		457	501	510	
LSD (P=0.05)	Variety			8.4				3.0				8.4				11.3
	DOHK			8.4				3.0				8.4				11.3
	Interaction (Variety × DOHK)			14.6				5.2				14.6				NS

*DOHK, Date of haulm killing

(293 t/ha), with a harvest of 90 days, produced the highest 25–125 g tubers. For eight, Kufri Jyoti (14.85 t/ha) and Kufri Gaurav (15.76 t/ha) recorded figures that were much higher than Kufri Lauvkar (11.18 t/ha). Total and main-grade tuber production significantly increased as harvest was postponed from 75 to 85 and 95 days (Rex 1991). Haulm cutting at 65 DAP increased the seed grade size yield at 5% level of significance under Kalyani conditions of WB (Mandal and Das 2020). It is reported that under tropical climatic condition, the tuber weight of potato cultivars increase up to 80 days and decreases slowly after 90 days. With the rise of temperature in the month of late February or March, potato storage food used in reverse order from tuber to foliage (Sadawarti *et al.* 2022). Significant variation was observed in the total weight of tuber per hill by the combined effect of date of planting and dehaulming (Alam *et al.* 2017).

Total tubers: For the total tuber number, Kufri Gaurav (646 thousand per ha) and Kufri Jyoti (450 thousand per ha) recorded significantly higher numbers than Kufri Lauvkar (373 t/ha). Delayed haulm killing, i.e. 90 days (510 t/ha) followed by 80 days (501 t/ha), noticed a considerable rise in total tubers over 70 days haulm killing (457 t/ha). In Hassan Karnataka conditions, a similar rise in yield and number of tubers was attained by delaying haulm killing by up to 90 days in Kufri Pukhraj (Kumar *et al.* 2009). When haulm killing has been carried out at 90 DAP as compared to early removal of haulm in Kufri Pukhraj, the total number of tubers/plant and yield/ha were much more (7.74 and 19.7 t/ha, respectively) (Kumar *et al.* 2009). According to Sharkar *et al.* (2019), the 100 DAP harvest, processing potato produced the highest amount of tubers (33.31 t/ha), followed by the 90 (32.76 t/ha) and 80 DAP harvests (20.78 t/ha) in Bangladesh and up to 100 days in another study in Bangladesh (Alam *et al.* 2017). In comparison to other combinations, Kufri Gaurav recorded the highest total tuber weight after 90 days of haulm killing (33.16 t/ha). Mahmud *et al.* (2009) noted such variances in interaction. The results revealed that seed and non-seed grade tubers differed due to bulking period that regulates photosynthates transferred to tubers. The results are supported by the earlier findings of Kushwah and Singh (2008). They observed a significant variation in the total weight of tuber by the combined effect of date of dehaulming and the variety.

Percent seed size tubers: For seed size tuber per cent by number, Kufri Lauvkar (49.39), followed by Kufri Jyoti (48.30), recorded the highest tuber per cent over Kufri Gaurav (44.60). Multa scored the highest (72.6%), followed by Ailsa (71.82%) and Dheera (71.74%) in terms of seed tuber percentage, and a similar pattern in opposite order was noticed for the non-seed part under Bangladesh conditions (Mahmud *et al.* 2009). Between haulm killing days, 80 days (48.18) recorded non-significantly higher seed size tuber per cent over 90 days (47.29) and 70 days (46.81). Similar findings were reported by Sadawarti *et al.* (2022) where in higher per cent of seed size tubers were recorded in 80 days haulm killing over other haulm killing days. In interaction, 80 days of haulm killing in Kufri Lauvkar

Table 2 Effect of haulm killing dates and varieties on per cent seed size tubers and seed: non seed ratio

Variety/DOHK	Percent seed size tubers									Seed: non seed ratio										
	By Number			By weight			By Number			By weight			By Number			By weight				
	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean	70 days	80 days	90 days	Mean
Kufri Lauvkar	46.05	52.07	50.04	49.39	45.65	51.32	48.00	48.32	1.175	0.921	0.999	1.032	1.193	0.951	1.084	1.076	1.032	0.951	1.084	1.076
Kufri Jyoti	48.41	48.86	47.62	48.30	68.74	72.35	59.65	66.91	1.067	1.048	1.101	1.072	0.455	0.383	0.677	0.505	1.072	0.455	0.383	0.677
Kufri Gaurav	45.97	43.62	44.20	44.60	64.60	60.89	48.26	57.92	1.177	1.294	1.263	1.244	0.554	0.643	1.077	0.758	1.244	0.554	0.643	1.077
Mean	46.81	48.18	47.29		59.66	61.52	51.97		1.140	1.088	1.121		0.734	0.659	0.946					
LSD (P=0.05)		1.43			2.35				0.063				0.076							
		NS			2.35				NS				0.076							
		2.47			4.07				0.110				0.131							

*DOHK, Date of haulm killing

Table 3 Effect of haulm killing dates and varieties on health parameters

Variety	Mild Mosaic			Severe Mosaic			Off-type		
	1 st	2 nd	3 rd	1 st	2 nd	3 rd	1 st	2 nd	3 rd
Kufri Lauvkar	0.12	0.08	0.00	0.00	0.24	0.12	0.17	0.00	0.00
Kufri Jyoti	0.08	0.08	0.00	0.00	0.08	0.00	0.06	0.00	0.00
Kufri Gaurav	0.16	0.16	0.04	0.08	0.20	0.24	0.11	0.00	0.00
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
<i>DOHK</i>									
70 days	0.16	0.16	0.04	0.08	0.12	0.08	0.11	0.00	0.00
80 days	0.12	0.04	0.00	0.00	0.12	0.08	0.17	0.00	0.00
90 days	0.08	0.12	0.00	0.00	0.28	0.20	0.06	0.00	0.00
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
LSD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
<i>Interaction (DOHK × Variety)</i>									

*DOHK, Date of haulm killing

(52.07) recorded a greater seed tuber per cent significantly than other combinations (Table 2). Varietal differences in the seed-size tubers' development were reported in the seed potato production study (Sadawarti *et al.* 2019). A significant increase in small and large size tubers but a non-significant increasing trend in medium seed tubers were recorded with delay in haulm cut (Farahvash and Iranbakhsh 2009). In interaction, Kufri Jyoti, with 80 days haulm killing (72.35), observed significantly the greatest per cent of seed size tubers than other combinations (Table 2).

Seed: non-seed ratio: By a large margin, Kufri Lauvkar had the best seed-to-non-seed ratio (1.032), while Kufri Gaurav had the worst ratio (1.244). Similar to this, best seed: non-seed ratio was non-significantly best in 80 days haulm killing (1.088), and lowest in 90 days haulm killing (1.121). 80 days haulm killing in 60 cm × 20 cm spacing recorded best seed: non seed ratio (0.957) for number over poorest 80 and 90 days of haulm killing (Sadawarti *et al.* 2022). In comparison to other combinations, Kufri Lauvkar achieved significantly the best seed: non-seed ratio with an 80 days haulm killing (0.921). When compared to combinations, Kufri Jyoti's 80-day haulm killing (0.383) reported a much higher ratio of best seed to non-seed (Table 2). In the present study, variety × haulm killing combinations gave a maximum percent of non-seed tubers resulting in higher seed: non-seed combinations. Similar results were obtained by Mehmud *et al.* (2009) who found that 75 DAP had the lowest per cent of non-seed tubers (19.19%) and the lowest ratio of seed to non-seed tubers (1:0.237).

Health standards: Different genera of different soil borne, seed borne pathogen and many bacteria and fungus like *Rhizoctonia solani* (black scurf), *Phytophthora infestans* (late blight), *Phoma foveata* (gangrene) and *Verticillium dahliae* (Verticillium wilt) as well as bacterial diseases are controlled through the practice of haulm killing (Kempenaar and Struik 2007). It is essential to identify and remove mild mosaic severe mosaic, and off-types to produce breeder seeds

that are high-quality, disease-free, and suitable for further multiplication (Sadawarti *et al.* 2019). Non-significant variation was recorded for mild, severe mosaic, and off-types in varieties, haulm killing days, and their interactions (Table 3). Ninety days haulm killing (0.28 and 0.20% in 2nd and 3rd rouging) recorded a higher per cent of severe mosaic over the other two haulm killing days. Sadawarti *et al.* (2017) reported considerably greater mild and severe mosaic incidence with 80 days haulm cut (0.87%) over 70 days haulm cut (0.42%). Off-types were recorded only in the first rouging in varieties and in days to haulm killing days (Table 3). Overall, Kufri Jyoti and 80 days haulm killing days recorded lower mild, severe mosaic, and off-type. Based on Indian minimum seed certification standards, the maximum allowable limit for mild, severe, and off-types in each variety and days to haulm dying is 0.50% for foundation-1, 0.75% for foundation-2, and 1% for certified seed (IMSCS 2013).

Dehaulming improves tuber appearance, limits tuber size and improves tuber release from the vine; thus, facilitates harvest operations. The results suggest that the crop should be allowed to grow for 80 days to achieve the highest seed-sized tuber yield as well as the number of seed tubers. It could expose the crop to a lesser period of diseases and pests which results in a healthy seed crop.

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