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Ambikesh Tripathi
M. Sc. Scholar, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Ravi Shanker Singh
Assistant Professor, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Vineet Kumar Shukla
M. Sc. Scholar, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Bhayankar
M. Sc. Scholar, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Hariom Mishra
M. Sc. Scholar, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Corresponding Author:
Ambikesh Tripathi
M. Sc. Scholar, Department of Agronomy, Acharya Narendra Deva University of Agriculture and Technology Kumarganj Ayodhya, Uttar Pradesh, India

Effect of cut tubers technology and varieties on growth, yield and economics of potato (*Solanum tuberosum* L.)

Ambikesh Tripathi, Ravi Shanker Singh, Vineet Kumar Shukla, Bhayankar and Hariom Mishra

Abstract
The present investigation entitled **"**Effect of cut tubers technology and varieties on growth, yield and economics of potato (*Solanum tuberosum* L.)" was conducted at MES Vegetable Research Farm, Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Rabi* season of 2019-20. The experiment was laid out in Factorial Randomized block design with three replications keeping two varieties, Kufri Sadabahar and Kufri Ashoka and four tuber treatment viz., cut tuber (60x10cm), cut tuber (60x15cm), cut tuber (60x20cm), whole tuber (60x20cm).
Results revealed that among tuber treatments application of Kufri Sadabahar variety with cut tuber (60x10cm) proved superior to other treatments with respect to higher crop growth, yield and yield attributes, Maximum gross return (283200.00), net return (202285.00) and cost of cultivation (80915.00) and benefit cost ratio (2.50) was found with the application of Kufri Sadabahar variety with cut tuber (60x10cm) treatment combinations.

Keywords: Cut tuber, potato, growth parameter and yield parameter

1. Introduction
Potato *(Solanum tuberosum* L.), popularly known as "The King of Vegetables" is a native of Peru and covered the largest area under vegetable crop in the world. Recently, developing countries of Asia accounts for more than 46% of global output. Potato is a very nutritious tuber vegetable and is rich in starch, vitamin B, C and minerals. Average, 100 g of potato raw with skin contains carbohydrates 19 gm, starch 15 gm, dietary fiber 2.2 gm, energy 321 Kcal, fat 0.1 gm, protein 2 gm, water 75 gm, thiamine 0.08 mg, riboflavin 0.03 mg, vitamin B_6 0.25 mg, vitamin C 20 mg, vitamin A 2 mg, vitamin E 0.01 mg, vitamin K 1.9 mg, calcium 12 mg, magnesium 23 mg, phosphorous 57 mg, iron 1.8 mg, potassium 421 mg, sodium 6 mg and sugar 0.78 mg (Bharali 2017) [1].
The current global production of potato is around 388.2 million tones and China being the biggest producer globally, India ranks 2nd in area and production of potato after the China which contribute 11 percent of the world potato production. Whereas total area in India under potato cultivation is 1.84 million hectare and production is 50.33 million tonnes with productivity of 27.31 tonnes per hectare. In India potato production is meanly confined to Uttar Pradesh, West Bengal, Punjab, Assam, Gujarat and Haryana. The contribution of U.P. alone in area, production and productivity 0.61 million hectare, 13.9 million tonnes and 22.7 tonnes per hectare respectively (Anonymous 2019-2020). Total tuber yield was highest with cut tubers planted at 4 tonnes ha^{-1}. This treatment also gave the highest yield of seed size tubers of< 25 g and 25-75 g size. The lowest total tuber yield was given by planting whole tuber at 2 tonnes ha^{-1} (Singh 1998) [2].
Cutting seed has been adopted in Senegal because of the lack of adequate availability of seedlings whole seed but also by reducing the seed cost. However, cut surface may be susceptible to attack by soil-borne fungi, particularly during the cool and wet conditions. Whole seed tubers of potato (*Solenum tuberosum* L.) have been reported to have some performance advantages over seed pieces produced by cutting whole tubers, even if the cut seed is treated with a fungicide dust (Kawakami *et al*., 2003) [3]**.** Research and commercial production history have shown that potato seed piece (> 50 g) may influence plant development and yield (Arsenault and Christie 2004) [4]
The number and weight of rotted tubers was recorded higher in variety Kufri Sadabahar (6.97% and 7.83%, respectively) than KufriSurya (6.94% and 7.81%, respectively), however the variation was found non-significant. (Fontes*etal*. 2010) [5].

Cutting seed has been adopted in Senegal because of the lack of adequate availability of seedlings whole seed but also by reducing the seed cost. Cutting of seed is commonly adopted in some situation, especially if the seed size is large. This is done in order to save seed to improve the multiplication rate, to improve the distribution of stem population, to increase the number of stems per seed tuber and to stimulate sprout growth. Cut seed affects the economy in seed, and cutting of seed towards the end of its dormancy stimu1ates sprouting and improves the plant stands.

2. Method and Material

The experiment was conducted at Vegetable research farm Acharya Narendra Deva University of Agriculture and Technology, Kumarganj, Ayodhya (U.P.) during *Rabi* season of 2019-20. The soil of the experimental field was silt loam in texture with medium soil fertility.

The experiment was laid out in Factorial Randomized Block design with three replications keeping two varieties, Kufri Sadabahar and Kufri Ashoka and four tuber treatment viz., cut tuber (60x10cm), cut tuber (60x15cm), cut tuber (60x20cm), whole tuber (60x20cm).

3. Result and Discussion

For this experiment the data were statistically analyzed and presented with the help of table. Following result should beobtainedin this experiment.

3.1 Growth attributes

The data pertaining to plant height are summarized in Table1.There was progressive increase in plant height with increase in age of crop up to 90 DAP and then slowed down a th harvest. There after indicating tha TGR and growth period lies between 30-90 DAP. Scanning of Table 1 clearly found that Plant height was found significant at all the stage of crop growth as influenced by varieties. Plant height was found non-significant at all the stage of crop growth except 30days after planting which was significant as influenced by different tuber treatments. At 30 days after planting the cut tuber 60x10 cm (S_1) attain maximum height is 29.10cm due to the closer spacing of plants are compete for sunlight and attain maximum height in comparison to rest of the spacing. Number of leaves was found significant at all the stage of crop growth as influenced by different tuber treatments. Whole tuber (S_4) produce maximum number of leaves at all the stage of crop growth. The number of leaves was produce from whole tuber is (29.20), (64.90) and (57.00) at 30, 60 and 90 days after planting due to the whole tuber having more number of eyes so they produces large number of haulms that was directly affect the number of leaves. Similar results also proposed by Kushwah and Grewal 1990 [6].

Table 1: Plantheight (cm) and Number of leaves (m^{-1}) asinfluenceby Cut seed tuber technology and varieties of potato

Treatments	Plant height (cm)			Number of leaves (m^{-1})		
	30 DAP	60 DAP	90 DAP	30 DAP	60 DAP	90 DAP
Varieties						
Kufri Ashoka	25.00	45.45	47.70	27.60	55.10	44.10
Kufri Sadabahar	27.48	50.50	53.00	23.90	59.50	56.55
SEm±	0.48	0.82	0.90	0.37	0.99	0.87
CD 5%	1.47	2.48	2.70	1.11	2.98	2.59
Seed tuber Distance						
Cut Tuber (60X10)cm	29.10	51.10	53.70	21.60	48.20	42.20
Cut Tuber (60X15)cm	26.70	48.30	50.60	25.30	56.40	49.60
Cut Tuber (60X20)cm	25.00	46.50	48.80	26.90	59.70	52.50
Whole Tuber (60X20)cm	24.15	46.00	48.30	29.20	64.90	57.00
SEm±	0.63	1.06	1.16	0.48	1.28	1.11
CD 5%	1.89	NS	NS	1.43	3.84	3.35

Data pertaining to dry weight of haulm of potato was mentioned in table 2. Dry weight of haulms was found significant at all the stage of crop growth as influenced by different tuber treatments and varieties. Whole tuber (S_4) produce more dry weight at all the stage of crop growth. The Dry weight of haulms was produce from whole tuber is (9.33g), (33.90) and (38.15) at 30, 60 and 90 days after planting because of whole tuber produces large number of haulm due to the number of eye in whole tuber is more so the dry weight of whole tuber is more. This was also proposed by Zebeny 2015 [7].

Table 2: Dry weight of haulms of Potato as influenced by Cut seed tuber technology and varieties

Treatments	Dry wt. of haulms(gm^{-1})		
	30 DAP	60 DAP	90 DAP
Varieties			
Kufri Ashoka	8.58	28.53	31.35
Kufri Sadabahar	7.83	31.15	35.83
SEm±	0.12	0.46	0.60
CD 5%	0.37	1.40	1.80
Seed tuber distance			
Cut Tuber (60X10)cm	7.03	25.65	28.85
Cut Tuber (60X15)cm	7.75	28.20	31.75
Cut Tuber (60X20)cm	8.70	31.60	35.60
Whole Tuber (60X20)cm	9.33	33.90	38.15
SEm±	0.16	0.60	0.77
CD 5%	0.49	1.81	2.33

3.2 Yield attributes and yield

The data pertaining on number of tuber hill^{-1} was recorded after harvest and mention in Table 3. Number of tuber found significant at all graded tuber except 25-50g tuber that was found non-significant as influenced by different tuber treatments and varieties. Maximum number of 0-25g grade tuber (6.40) was found in (S_1) treatment and at 25-50g, 50- 75g and >75g graded tuber, whole seed (S_4) treatment produce maximum tuber (5.70), (2.70) and (2.50), respectively. When the density of tuber is increased the total number of tuber will also be increased. This change is also due to the genetic makeup of vaieties and that will be also proposed by Zebenay, 2015

Table 3: Number of tuber of Potato as influenced by Cut seed tuber technology and varieties

Treatments	Number of tuber (hill^{-1})			
	0-25 g	25-50 g	50-75 g	>75 g
Varieties				
Kufri Ashoka	4.96	5.14	2.23	2.21
Kufri Sadabahar	4.85	5.75	2.65	2.55
SEm±	0.06	0.10	0.04	0.04
CD 5%	**NS**	0.30	0.12	0.13
Seed tuber distance				
Cut Tuber (60X10) cm	6.40	5.60	2.40	2.30
Cut Tuber (60X15) cm	4.50	5.20	2.30	2.20
Cut Tuber (60X20) cm	4.40	5.30	2.40	2.50
Whole Tuber (60X20) cm	4.30	5.70	2.70	2.50
SEm±	0.08	0.13	0.05	0.05
CD 5%	0.24	**NS**	0.16	0.17

The data pertaining on weight of tuber g hill^{-1} was recorded after harvest and presented in Table 4. Weight of tuber found significant at all graded tuber except 25-50g tuber that was found non-significant as influenced by different tuber treatments. Maximum Yield of 0-25g grade tuber (64.40g) was found in (S_1) treatment and at 25-50g, 50-75g and >75g graded tuber, whole seed (S_4) treatment produce maximum tuber yield (171.50g), (148.50g) and (203.50g), respectively.

The maximum weight of 50-75g and >75 g tuber was produced 148.50g and 203.50g hill^{-1} from the treatment whole tuber 60x20cm at par with cut tuber 60x10cm which produce 147.00g and 200.00g tuber hill^{-1} and that was significant over rest of the treatments. The percentage of medium size tubers increased with cut tubers and the percentage of large size tubers decreased. There were no differences in overall yield per hectare between cut and whole tubers. Similar results also proposed by Kushwah and Grewal 1990 and when the density of plant will increased the size of tuber was decreased. This results was proposed by Zebenay, 2015.

Table 4: Weight of tuber of Potato as influenced by Cut seed tuber technology and varieties

Treatments	Weight of tuber (g hill^{-1})			
	0-25 g	25-50g	50-75 g	>75 g
Varieties				
Kufri Ashoka	50.70	156.00	136.00	186.75
Kufri Sadabahar	51.34	173.25	145.25	202.25
SEm±	0.86	2.65	1.78	2.89
CD 5%	**NS**	7.95	5.33	8.67
Seed tuber distance				
Cut Tuber (60X10)cm	64.40	170.00	147.00	200.00
Cut Tuber (60X15)cm	48.98	158.50	132.00	185.50
Cut Tuber (60X20)cm	38.60	158.50	135.00	189.00
Whole Tuber(60X20)cm	52.10	171.50	148.50	203.50
SEm±	1.11	3.42	2.29	3.73
CD 5%	3.35	**NS**	6.89	11.20

The data pertaining on tuber yield and haulm yield of Potato was recorded after harvest and presented in Table 5. Tuber and haulm yield of potato as influenced by varieties and different tuber treatments was found significant. As in table 5 the yield of cut tuber (60x10cm) as in cut tuber technology was significantly higher than cut tuber (60x15cm), (60x20cm) and whole tuber (60x20cm) treatments. Which shows that cut tuber 60x10cm produce maximum 453.50 q ha^{-1} yield while cut tuber (60x15cm), (60x20cm) produce only 409.50 and 406.50 and the whole tuber also produce higher yield but as compare to cut tuber (60x10cm) it was produce 3.5 q ha^{-1} less yield.

The maximum tuber yield was produced 453.50 q ha^{-1}from the treatment cut tuber 60x10cm at par with whole tuber 60x20cm which produce 449.00 q ha^{-1} tuber and that was significant over rest of the treatments, that produce 409.50 and 406.50 q ha^{-1} tuber, respectively. The percentage of medium size tubers increased with cut tubers and the percentage of large size tubers decreased. There were no differences in overall yield per hectare between cut and whole tubers. It may be also reported by Kushwah and Grewal 1990 Sylla *et al.* 2019 [8] and Coraspe and Cortayer 1994 [9].

Table 5: Tuber yield and haulm yield of Potato as influenced by Cut seed tuber technology and varieties

Treatments	Yield (q ha^{-1})	
	Tuber Yield	Haulm Yield
Varieties		
Kufri Ashoka	413.00	308.88
Kufri Sadabahar	446.25	336.13
SEm±	8.56	7.27
CD 5%	25.68	21.79
Seed tuber distance		
Cut Tuber (60X10)cm	453.50	288.20
Cut Tuber (60X15)cm	409.50	307.40
Cut Tuber (60X20)cm	406.50	322.55
Whole Tuber (60X20)cm	449.00	371.85
SEm±	11.06	9.38
CD 5%	33.16	28.14

3.3 Economics

The economic analysis included the cost of cultivation (Rs ha^{-1}), gross returns (Rs ha^{-1}), net returns (Rs ha^{-1}) and benefit: cost ratio (Rs Re^{-1}) under different treatments combination of different tuber treatments and varieties for potato crop as a whole is done in present investigation. Data of the economics analysis are summarized in table 6.

Highest cost of cultivation was 80915 Rs ha^{-1} in T_1, T_4, T_5 and T_8

while the minimum cost of cultivation was Rs. 74915 in T_3 and T_7 treatments. The highest gross return was found in T_5 treatment which is 283200 Rs ha^{-1} while minimum gross return was found in T_3 treatment which is only 235200 Rs ha^{-1}.The maximum net return was found in T_5 treatment which is 202285 Rs ha^{-1} while minimum net return was received in T_2 treatment which is 159085 Rs ha^{-1}. Highest benefit: cost ratio was found in treatment T_5 which is 2.50, while the minimum benefit: cost ratio was found in T_2 treatment which is only 2.05.

Table 6: Economics of various treatments combinations

Sr. No.	Treatment	Common cost	Variable cost	Total cost	Gross return	Net return	B:C
1	V_1S_1	44915.00	36000.00	80915.20	261000.00	180085.20	2.22
2	V_1S_2	44915.00	32400.00	77315.20	236400.00	159085.20	2.05
3	V_1S_3	44915.00	30000.00	74915.20	235200.00	160285.20	2.13
4	V_1S_4	44915.00	36000.00	80915.20	258600.00	177685.20	2.19
5	V_2S_1	44915.00	36000.00	80915.20	283200.00	202285.20	2.50
6	V_2S_2	44915.00	32400.00	77315.20	255000.00	177685.20	2.29
7	V_2S_3	44915.00	30000.00	74915.20	252600.00	177685.20	2.37
8	V_2S_4	44915.00	36000.00	80915.20	280200.00	199285.20	2.46

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