HSPI The Open Access Publisher

JOURNAL OF PLANT SCIENCE AND PHYTOPATHOLOGY
ISSN 2575-0135

Research Article

Evaluation of Seed Potato (*Solanum tuberosum* L.) Production from Stem Cutting and Conventional Seed Tubers

Kyenpiya E Deshi[1]*, Gloria M Philibus[2], Vou M Shutt[2] and Sisunya Habila[2]

[1]TetFund Centre of Excellence in Food Security, University of Jos, Nigeria

[2]Department of Plant Science and Biotechnology, Faculty of Natural Sciences, University of Jos, Nigeria

Abstract

This study was carried out to evaluate seed potato production from stem cuttings and conventional seed tubers in Jos, Plateau State, Nigeria in the year 2021. The experiment was laid out in a completely randomized design consisting of three potato varieties (Nicola, Caruso, and Lady Christl), two methods (conventional seed tubers and stem cuttings), and two periods of stem cuttings (first and second) giving a total of 12 treatment combinations replicated three times. The data obtained was subjected to analysis of variance and the means were separated using $LSD_{0.05}$. The results showed that establishment count, mean plant height, and the mean number of leaves were significantly ($p < 0.05$) affected by variety and stem-cutting periods. The total number and total yield of tubers formed were significantly affected by both variety and method (stem cutting and conventional). Stem cutting method had a significantly higher mean total number and weight of tubers formed (84.88 and 913.22 g respectively) than the conventional seed tubers method (52.77 and 761.22g respectively), the total number of ware tubers formed were similar in both stem-cutting method and conventional seed tuber method, however conventional tuber method had significantly ($p < 0.05$) higher weight of ware tubers than stem cutting method. The stem-cutting method had a significantly ($p < 0.05$) higher number and weight of seed tubers (78.55 and 663.66 g) respectively than the conventional seed tuber method (46.88 and 518.55 g). It can be concluded that stem-cutting is a better alternative to rapidly multiply seed potatoes than conventional seed tuber propagation since it yields higher seed tubers.

More Information

***Address for correspondence:** Kyenpiya E Deshi, TetFund Centre of Excellence in Food Security, University of Jos, Nigeria, Email: kdeshi@yahoo.com

Submitted: February 04, 2025
Approved: February 26, 2025
Published: February 27, 2025

How to cite this article: Deshi KE, Philibus GM, Shutt VM, Habila S. Evaluation of Seed Potato (*Solanum tuberosum* L.) Production from Stem Cutting and Conventional Seed Tubers. J Plant Sci Phytopathol. 2025; 9(1): 001-010. Available from: https://dx.doi.org/10.29328/journal.jpsp.1001147

Keywords: Potato; Growth; Multiplication ratio; Seed multiplication; Yield

Introduction

Potato (*Solanum tuberosum* L.) is a major food crop after wheat, maize, and rice [1], as annual production is about 380 million tons on 18 million hectares of land worldwide [2]. Potato stands out as a significant crop in improving food security and doubles as a staple for over 1 billion people globally [3,4]. Potato has the ability to provide better yield per unit input with a shorter crop cycle [5]. In developing countries where Nigeria is a part of, potato is used both as food and cash crop as it contributes significantly to national food security and nutrition, poverty alleviation, and income generation, as well as providing employment in the production, processing, and marketing sub-sectors [6].

The major constraints of potato production include: a shortage of cultivars that are well-adapted for the major agro-ecological zones, insufficient and high cost of seed tubers, good agronomic practices, the occurrence of pest and diseases impairing yield, and poor post-harvest storage of both seed and ware tubers [7-9]. The shortage of healthy and quality seed tubers in the required quality and timely contributes to the low productivity of potatoes [10].

It has been established that potato propagation is both via sexual means by botanical seed called true potato seed (TPS) and asexual (vegetatively) by means of tubers [11,12]. Currently, tubers are the most common method of potato multiplication of potato crop in developing countries [13]. Even though potato production using conventional seed tubers could have a low multiplication ratio [14,15]. Seed potato constitutes 40-50% of the total variable cost in potato production [16]. This results in high costs and a shortage of seeds for mass production and consumption [17,18]. It is advised that seed tubers with good vigor are used, as seed vigor of potatoes determines their potential for rapid growth and even germination, good emergence, and proper plant development hence their future productivity [19]. Sometimes, this encourages the spread of tuber-borne diseases, low multiplication rate, and requires many seed tubers per hectare. This has led to significant losses in yield and tuber quality over the seasons [20].

Tissue culture is another method that enables multiplied seed potato tubers to be rapidly produced of the required quality and quantity of seed [21]. However, tissue culture requires high technology and high capital especially for small-scale farmers [22,23]. There is therefore a need to evaluate alternative methods of multiplication which will be both acceptable and affordable for these small-holder farmers.

The use of shoot tip cuttings has also been reported as a rapid multiplication technique that has been used to produce more cuttings from one mother plant. These cuttings are grown into multiple plantlets within a short time as the cycle continues, it reduces direct contact with soil-borne and is more affordable [21,24].

Stem cuttings have also been used for rapid propagation and are able to produce 20 to 60 cuttings from each parent plant. It was reported [25] that the use of potato stem cuttings which is an asexual means of vegetative propagation is very promising. This takes out the need to break seed dormancy, the high seed cost, and the problem of storage and transportation in the conventional method. The use of stem cuttings to propagate potatoes not only increases the multiplication ratio but also reduces potato production costs [26]. This research therefore aims at assessing seed potato production from stem cuttings and conventional seed tubers.

Materials and methods

The study was carried out between the months of May to October 2021 at Ritdun Integrated Farm Resources, Kangang Road, off Miango Road, Dadin Kowa, Jos, Plateau State, Nigeria (Latitude 09°85ᴵ N, Longitude 08°86ᴵ E and Altitude 1317 meters above sea level), under rainfed conditions (see meteorological data, Appendix 1), to evaluate seed potato production from stem cuttings and conventional seed tubers.

Three popular varieties used by the potato farmers viz: Nicola, Caruso, and Lady Christl were obtained from the National Root Crops Research Institute (NRCRI) Kuru, Jos, Plateau State Nigeria.

The experiment was laid out in a completely randomized design consisting of three potato varieties (Nicola, Caruso, and Lady Christl), two methods (conventional seed tubers and stem cuttings), and two periods of stem cuttings (first and second) giving a total of 12 treatment combinations which was replicated three times.

Soil preparation was carried out on the 29th of May, 2021. Topsoil was mixed with goat droppings in a ratio of 3:1 and steam sterilized to eliminate soil-borne pathogens and kill seeds of weeds. The sterilized soil mixture was filled into polyethylene pots for the planting of seed potato tubers and subsequent transplanting of potato stem cuttings. One seed tuber which was at multiple sprout stages was planted per pot on 30th May 2021.

Apical stem cuttings were made from the potato plants three weeks after planting according to the work of Nikmatullah, et al. [27]. Three nodes were cut using sterilized blades and the leaves were trimmed, leaving only the apical leaf and two subsequent leaves. The cuttings were planted 5 cm apart to avoid entangling of roots according to [28]. The first cuttings were made on 20th June 2021 and the second cuttings were made 15 days after the first cutting.

The cuttings were transplanted 14 days after cuttings were made when they had formed roots and were established. Each cutting was transplanted to an individual pot, and the cuttings were placed deep covering two leaf nodes with soil to control the number of stems according to a study [28]. Weeding was done by hand-picking as often as required.

The parameters assessed were: Establishment count of cuttings (obtain by dividing the number of established cuttings by total number of cuttings made and multiplying by one hundred), plant height of established cuttings, number of leaves of established cuttings, total number of tubers formed,

Appendix 1: Weather Reading for 2021 in Jos, Plateau State, Nigeria

Month	Temperature (°C)		Humidity (%)	Rainfall (mm)	Rainy days
	Minimum	Maximum			
January	17.00	24.00	35	0.07	0.00
February	20.00	26.00	38	2.72	0.90
March	22.00	26.00	43	22.80	3.60
April	22.00	27.00	65	82.90	13.80
May	23.00	26.00	74	197.30	24.10
June	22.00	29.00	81	246.10	27.70
July	21.00	29.00	85	372.1	31.80
August	18.00	25.00	87	432.00	31.30
September	19.00	24.00	75	325.30	29.80
October	21.00	24.00	68	183.10	18.30
November	21.00	25.00	57	1.41	0.30
December	18.00	23.00	44	0.27	0.20

Source: Federal College of Forestry, meteorological station, Jos, Plateau State, Nigeria. Note: Temperature values represent average daily temperatures number of ware tubers formed, number of seed tubers formed, total weight of tubers formed, weight of ware tubers formed and weight of seed tubers formed. The data obtained was subjected to analysis of variance (ANOVA) using Minitab software and the means were separated using LSD at a 5% level of probability [29].

Results

Establishment count of stem cuttings

Variety had a significant ($p < 0.05$) effect on mean establishment count at 2 and 4 weeks after cutting. The variety Caruso had the highest mean establishment count (78.82%) while variety Lady Christl and variety Nicola had similar mean establishment counts at 2 weeks after cutting. However, at 4 weeks after cutting variety, Caruso had a significantly higher mean establishment count (57.83%) followed by variety Nicola (56.59) while variety Lady Christl had the lowest mean establishment count (51.82%) (Table 1).

The stem cutting period had a significant ($p < 0.05$) effect on mean establishment count both at 2 and 4 weeks after cuttings. At 2 weeks after cutting, the second cutting period had significantly ($p < 0.05$) higher mean establishment count (83.33%) than the first cutting which hard 69.44% however, at 4 weeks after cutting, the first cutting period had significantly ($p < 0.05$) higher mean establishment count (56.49%) than second stem cutting period which had 54.33%. (Table 1).

Plant height of stem cuttings

Plant height was significantly ($p < 0.05$) affected by variety. At two weeks after cuttings, variety Nicola resulted in the highest mean plant height (10.01 cm) followed by variety Lady Christl (9.43 cm) while variety Caruso had the lowest mean plant height (6.92 cm) and their difference is significant($p < 0.05$). However, at 4 weeks after cuttings were made, variety Nicola had the highest mean plant height while Lady Christl had the lowest mean plant height (18.13 cm) and the difference was significant ($p < 0.05$) (Table 2).

Table 1: Effect of variety as affected by cutting period on percentage establishment of potato cuttings at 2 and 4 weeks after cutting during the 2021 season in Jos.

Treatment	Establishment count of Stem cuttings	
Variety	**2 WAC**	**4 WAC**
Nicola	75.08b	56.59b
Caruso	78.82a	57.83a
Lady Christl	75.26b	51.82c
LS	*	*
$LSD_{0.05}$	2.00	1.21
Stem cuttings		
First cutting	69.44b	56.49a
Second cutting	83.33a	54.33b
LS	*	*
$LSD_{0.05}$	3.15	1.47

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at 5% probability level; LS: Level of Significance; NS: Not Significant
*Significant at 5% probability level; LSD: Least Significant Difference; WAC: Weeks after Cutting

The stem cutting period had a significant ($p < 0.05$) effect on mean plant height at 2 weeks after cutting but was not significant at 4 weeks after cuttings were made. At 2 weeks after cutting, the second cutting period resulted in significantly ($p < 0.05$) higher mean plant height (9.12 cm) than the first cutting period (8.45 cm) (Table 2).

The interaction between variety and stem cutting period was significant ($p < 0.05$) at both 2 and 4 weeks after cuttings were made (Table 2).

The interaction of variety and stem-cutting period on mean plant height is presented in Table 3. Two weeks after cutting, variety Nicola attained the longest height (10.85 cm) in the first cutting period while variety Lady Christl attained the longest height (12.44 cm) in the second cutting period (Table 3). However, four weeks after cutting, variety Caruso attained the longest height (26.22 cm) in the first cutting period while variety Nicola attained the longest height (29.12 cm) in the second cutting period (Table 3).

Number of leaves of stem cuttings

Variety significantly ($p < 0.05$) affected the number of leaves formed at both 2 and 4 weeks after cutting. Two weeks after cuttings were made, variety Nicola had the highest mean number of leaves produced (8.10) followed by variety Caruso (7.80) while variety Lady Christl produced the lowest mean number of leaves (5.50) and their difference was significant ($p < 0.05$) (Table 2). However, at 4 weeks after cuttings were made, variety Nicola had the highest mean number of leaves produced (14.86), followed by variety Lady Christl (11.86) while variety Caruso had the least mean number of leaves produced (10.40) and their difference was significant ($p < 0.05$) (Table 2).

Table 2: Effect of variety and stem cutting period on mean plant height (cm) and number of leaves produced by potato cuttings at 2 and 4 weeks after transplanting during 2021 season in Jos.

	Plant Height of Stem Cuttings (cm)		Number of Leaves	
	Weeks after cutting		Weeks after cutting	
	2	4	2	4
Variety				
Nicola	10.01a	28.05a	8.10a	14.86a
Caruso	6.92c	21.89b	7.80b	10.40c
Lady Christl (V3)	9.43b	18.13c	5.50c	11.86b
LS	*	*	*	*
$LSD_{0.05}$	0.56	0.64	0.17	0.35
Stem cuttings				
First cutting	8.45b	21.85a	7.33a	12.33a
Second cutting	9.12a	21.55a	6.93b	12.46a
LS	*	NS	*	NS
$LSD_{0.05}$	0.5	0.77	0.21	0.42
Interaction of Variety x stem cutting period	*	*	*	NS

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at 5% probability level; LS: Level of Significance; NS: Not Significant
*Significant at 5% probability level; LSD: Least Significant Difference

The stem cutting period had a significant ($p < 0.05$) effect on the mean number of leaves produced by cuttings at 2 weeks after cuttings were made but was not significant ($p < 0.05$) at 4 weeks after cuttings were made. At 2 weeks after cuttings were made, the first cutting period resulted in significantly ($p < 0.05$) higher mean number of leaves (7.33) than the second cutting period (6.93) (Table 2).

The interaction between variety and stem cutting period is significant ($p < 0.05$) at 2 weeks after cuttings were made, however, not significant ($p < 0.05$) at 4 weeks after cuttings were made (Table 2).

The interaction of variety and stem-cutting period on the mean number of leaves is presented in Table 3. Two weeks after cutting, variety Nicola produced the highest number of leaves (9.40) in the first cutting period, while variety Caruso produced the highest mean number of leaves (9.40) in the second cutting period (Table 3).

Total number of tubers formed

Variety significantly ($p < 0.05$) affected the mean total number of tubers formed (Table 4). Variety Lady Christl produced the highest mean total number of tubers formed (55.66), this was followed by variety Nicola (50.33) while variety Caruso had the lowest mean total number of tubers (31.66) and their difference was significant ($p < 0.05$) (Table 4).

Methods of seed multiplication had a significant ($p < 0.05$) effect on the mean total number of tubers formed. Stem cutting method produces a significantly ($p < 0.05$) higher mean total number of tubers (84.88) than the conventional seed tuber method (52.77) (Table 4).

The stem-cutting period had a significant ($p < 0.05$) effect on total number of tubers formed. The second stem-cutting period had a significantly ($p < 0.05$) higher mean number of tubers (58.55) than the first stem-cutting period (26.33) (Table 4).

The interaction variety X method was not significant. However, the interaction of the variety X stem cutting period was significant ($p < 0.05$) (Table 4).

The interaction of variety X stem cutting period on the mean total number of tubers produced is presented in Table 5. Variety Nicola produced the highest total mean number of tubers in the first stem cutting period (27.67), while, variety Lady Christl produced the highest total number of tubers in the second cutting period (79.67) (Table 5).

Number of ware (Sellable/Table potato for consumption) tubers formed

Variety had a significant ($p < 0.05$) effect on the mean total number of ware tubers formed. Variety Nicola had the highest mean total number of ware tubers (4.88), it was followed by variety Caruso (3.33) while variety Lady Christl had the lowest mean total number of ware tubers (2.88) and their difference was significant ($p < 0.05$) (Table 4).

Methods of seed tuber multiplication (Conventional seed tuber and stem cutting) did not have a significant ($p < 0.05$) effect on the total number of ware tubers formed (Table 4).

The stem-cutting period had a significant ($p < 0.05$) effect on mean number of ware tubers formed. The first stem-cutting period produced a significantly ($p < 0.05$) higher number of ware tubers (3.22) than the second stem cutting (2.33) (Table 4).

The interactions between variety X method, and variety X stem cutting period on mean number of ware tubers were significant ($p < 0.05$) (Table 4).

The interaction of variety X stem cutting period on a number of ware tubers produced is presented in Table 5. Variety Lady Christl produced the highest number of ware tubers in the first stem-cutting period (4.30). While variety Nicola was highest in the second stem-cutting period (4.67) (Table 5).

Table 3: Interaction of variety and stem cutting period on mean plant height (cm) and mean number of leaves produced at two and four weeks after cuttings.

	Weeks after cutting			
	2		4	
Treatment	Stem cutting period		Stem cutting period	
Variety	First cutting	Second cutting	First cutting	Second cutting
Plant Height (cm)				
Nicola	10.85a	9.16b	20.98b	29.12a
Caruso	8.07b	5.76c	26.22a	17.56c
Lady Christl	6.43c	12.44a	18.37c	17.93b
$LSD_{0.05}$	0.15		0.21	
Number of Leaves				
Nicola	9.40a	6.80b		
Caruso	6.20c	9.40a		
Lady Christl	6.40b	4.60c		
$LSD_{0.05}$	0.06			

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at a 5% probability level; LSD: Least Significant Difference.

Table 4: Effect of variety as affected by the method of seed multiplication and stem cutting period on the total number of tubers formed, number of ware tubers, and number of seed tubers formed during the 2021 season in Jos.

Treatment	Number of tubers formed		
	Total number of tubers	Number of ware tubers formed	Number of seed tubers formed
Variety			
Nicola (V1)	50.33b	4.88a	45.11b
Caruso (V2)	31.66c	3.33b	28.22c
Lady Christl (V3)	55.66a	2.88c	52.11a
LS	*	*	*
$LSD_{0.05}$	0.93	0.12	0.93
Methods			
Conventional seed tubers (M1)	52.77b	5.55a	46.88b
Stem cuttings	84.88a	5.55a	78.55a
LS	*	NS	*
$LSD_{0.05}$	1.21	0.16	1.19
Stem cuttings Period			
First cutting (S1)	26.33b	3.22a	22.33a
Second cutting (S2)	58.55a	2.33b	56.20b
LS	*	*	*
$LSD_{0.05}$	1.21	0.16	0.16
Interaction			
Variety x Method	NS	*	*
Variety x Stem cutting period	*	*	*

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at 5% probability level; LS: Level of Significance; NS: Not Significant
*Significant at 5% probability level; LSD: Least Significant Difference

Table 5: Interaction of Variety and Stem Cutting Period on Total Number of Tubers Formed, Number of Ware and Number of Seed Tubers Formed.

Treatment	Stem cutting period	
Variety	Cutting period 1	Cutting period 2
Total number of Tubers		
Nicola	27.67a	70.67b
Caruso	25.67b	25.33c
Lady Christl	25.67b	79.67a
$LSD_{0.05}$	0.70	
Number of ware tubers		
Nicola	3.33b	4.67a
Caruso	2.00c	1.00c
Lady Christl	4.30a	1.33b
$LSD_{0.05}$	0.10	
Number of seed tubers		
Nicola	23.33a	66.00b
Caruso	23.67a	24.33c
Lady Christl	20.00b	78.33a
$LSD_{0.05}$	0.70	

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at a 5% probability level; LSD: Least Significant Difference.

Table 6: Interaction of Variety and Method of Propagation on Mean Number of Ware and Number of Seed Tubers Formed

Treatment	Method of propagation	
Variety	Conventional seed tubers (M1)	Stem cutting (M2)
Number of Ware Tubers Formed		
Nicola	6.67b	4.00a
Caruso	7.00a	1.50c
Lady Christl	3.00c	2.83b
$LSD_{0.05}$	0.10	
Number of Seed Tubers Formed		
Nicola	23.33c	44.67b
Caruso	36.67b	24.00c
Lady Christl	58.00a	49.17a
$LSD_{0.05}$	0.70	

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at a 5% probability level; LSD: least significant difference.

The interaction of variety X method of propagation on the mean number of ware tubers produced is presented in Table 6. Variety Caruso produced the highest number of ware tubers in the conventional method of propagation. However, variety Nicola produced the highest number of ware tubers in the stem-cutting method of propagation (Table 6).

Number of seed tubers formed

Variety significantly ($p < 0.05$) affected the mean total number of seed tubers formed. Variety Lady Christl had the highest mean total number of seed tubers (52.11) which was followed by variety Nicola (45.11) while variety Caruso had the lowest mean total number of seed tubers (28.22) and their difference was significant ($p < 0.05$) (Table 4).

Methods of seed tuber multiplication (conventional seed tuber and stem cutting) affected the mean number of seed tubers produced significantly ($p < 0.05$). Stem cutting method resulted in a significantly ($p < 0.05$) higher mean total number of seed tubers (78.55) than the conventional seed tuber method (46.88) (Table 4).

The stem-cutting period had a significant ($p < 0.05$) effect on mean number of seed tubers produced. The second stem-cutting period produced significantly ($p < 0.05$) higher seed tubers (56.22) than the first stem-cutting period (22.33) (Table 4).

The interactions between the variety X method and variety X stem cutting periods on the mean number of seed tubers produced were significant ($p < 0.05$) (Table 4).

The interaction of variety X stem cutting period on the mean number of seed tubers produced is presented in Table 5. Variety Lady Christl produced the lowest number of seed tubers in the first cutting period (20.00), while, variety Caruso produced the lowest number of seed tubers in the second cutting period (24.33) (Table 5).

The interaction of variety X method of propagation on the mean number of seed tubers produced is presented in Table 6. Variety Nicola produced the least number of seed tubers in the conventional method of propagation, while, variety Caruso produced the least number of seed tubers in the stem-cutting method of propagation (Table 6).

Total fresh weight of tubers formed

Variety had a significant ($p < 0.05$) effect on the mean total weight of tubers formed. Variety Nicola resulted in the highest mean total weight (631.77 g), this was followed by variety Lady Christl (566.11 g) while variety Caruso resulted in the lowest mean total weight (476.33 g) and their difference was significant ($p < 0.05$) (Table 7).

Methods of seed tuber multiplication (conventional seed tuber and stem cutting) affected the mean total weight of tubers formed significantly ($p < 0.05$). Stem cutting method resulted in a significantly ($p <0.05$) higher mean weight of tubers formed (913.00 g) than the conventional seed tuber method (761.22 g) (Table 7).

The stem-cutting period had a significant ($p < 0.05$) effect on the mean total weight of tubers formed. First stem cutting resulted in a significantly ($p < 0.05$) higher weight of tubers (493.88 g) than second stem cutting (419.11 g) (Table 7).

The interaction of the variety X method of propagation was significant. However, the interaction of the variety X stem cutting period was not significant ($p < 0.05$) (Table 7).

The interaction of the variety X method of propagation on the mean total fresh weight of tubers produced is presented in Table 8. Variety Caruso had the highest mean total fresh weight (933.00 g) of tubers produced in the conventional method of propagation, while, variety Nicola had the highest total fresh weight of tubers (603.50 g) in the stem-cutting method of propagation (Table 8).

Weight of ware (sellable) tubers formed

Variety significantly ($p < 0.05$) affected the mean total weight of ware tubers formed. Variety Nicola resulted in a higher mean total weight (216.33 g), this was followed by variety Caruso (176.00 g) while variety Lady Christl produced the lowest mean weight of ware tubers (131.44 g) and their differences were significant ($p < 0.05$) (Table 7).

Methods of seed tuber multiplication (conventional seed tubers and stem cutting) had a significant ($p < 0.05$) effect on the mean total weight of ware tubers formed. The conventional seed tuber method resulted in significantly ($p < 0.05$) higher weight of ware tubers (268.33 g) than the stem cutting method (255.44 g) (Table 7).

Stem-cutting periods had a significant ($p < 0.05$) effect on the mean total weight of ware tubers formed. First stem cutting resulted in significantly ($p < 0.05$) higher mean weight of ware tubers (171.33 g) than second stem cutting (84.11 g) (Table 7).

The interactions between variety X method and variety X stem cutting periods were significant ($p < 0.05$) (Table 7).

Table 7: Effect of variety as affected by the method of propagation and stem cutting periods on the total weight of tubers formed, weight of ware tubers, and weight of seed tubers formed during the 2021 season in Jos.

Treatments	Total weight of tubers (g)	Weight of ware tubers (g)	Weight of seed tubers formed (g)
Variety			
Nicola (V1)	631.77a	216.33a	420.55b
Caruso (V2)	476.33c	176.00b	325.55c
Lady Christl (V3)	566.11b	131.44c	436.11a
LS	*	*	*
$LSD_{0.05}$	35.12	7.96	8.46
Methods			
Conventional seed tubers (M1)	761.22b	268.33a	518.55b
Stem cuttings (M2)	913.00a	255.44b	663.66a
LS	*	*	*
$LSD_{0.05}$	45.88	7.96	11.05
Stem cuttings Period			
First cutting (S1)	493.88a	171.33a	320.66b
Second cutting (S2)	419.11b	84.11b	343.00a
LS	*	*	*
$LSD_{0.05}$	45.88	7.96	11.05
Interaction			
Variety x Method	*	*	*
Variety x Stem cutting	NS	*	*

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at 5% probability level; LS: Level of Significance; NS: Not Significant
*Significant at 5% probability level; LSD: Least Significant Difference.

The interaction of variety X method of propagation on the fresh weight of ware tubers produced is presented in Table 8. Variety Caruso had the highest weight of ware tubers in the conventional method of propagation, while, variety Nicola produced the highest weight of ware tubers (189.67 g) in the stem-cutting method of propagation (Table 8).

The interaction of the variety X stem cutting period is presented in Table 9. Variety Lady Christl produced the highest fresh weight of ware tubers (232.67 g) in the first stem cutting period, while, variety Nicola produced the highest fresh weight of ware tubers (187.67 g) in the second cutting period (Table 9).

Weight of seed tubers formed

Variety had a significant ($p < 0.05$) effect on the mean total weight of seed tubers formed. Variety Lady Christl had a higher mean weight of seed tubers (436.11 g), it was then followed by variety Nicola (420.55 g) while variety Caruso resulted in the lowest mean weight of seed tubers (325.55 g) (Table 7).

Table 8: Interaction of variety and method of propagation on the total weight of tubers formed, weight of ware, and weight of seed tubers formed (g).

Treatment	Method of propagation	
Variety	Conventional seed tubers (M1)	Stem cutting (M2)
Total Weight of Tubers Formed (g)		
Nicola	688.33b	603.50a
Caruso	933.00a	248.00c
Lady Christl	662.33b	518.00b
$LSD_{0.05}$	26.79	
Weight of Ware Tubers Formed (g)		
Nicola	269.67b	189.67a
Caruso	414.33a	58.83c
Lady Christl	121.00c	136.67b
$LSD_{0.05}$	4.66	
Weight of Seed Tubers Formed (g)		
Nicola	429.33c	416.17a
Caruso	588.67a	194.00c
Lady Christl	537.67b	388.33b
$LSD_{0.05}$	6.46	

Means within the column with a difference equal to or greater than their LSD represented by alphabets a,b,c are significantly different at a 5% probability level; LSD: Least Significant Difference.

Table 9: Interaction of Variety and Stem Cutting Period on Total Weight of Tubers Formed, Weight of Ware, and Weight of Seed Tubers Formed.

Treatment	Stem cutting period	
Variety	Cutting period 1	Cutting period 2
Weight of ware tubers (g)		
Nicola	191.67b	187.67a
Caruso	89.67c	24.00c
Lady Christl	232.67a	40.67b
$LSD_{0.05}$	4.66	
Weight of seed tubers (g)		
Nicola	388.33a	444.00b
Caruso	277.67c	110.33c
Lady Christl	296.00b	474.67a
$LSD_{0.05}$	6.46	

Methods of seed multiplication (conventional seed tuber and stem cutting) significantly ($p < 0.05$) affected the mean weight of seed tubers formed. Stem cutting method produced significantly ($p < 0.05$) higher mean total weight of seed tubers (663.66 g) than the conventional seed tuber method (518.55 g) (Table 7).

Stem-cutting periods had a significant ($p < 0.05$) effect on the mean weight of seed tubers formed. The second stem-cutting period resulted in a significantly ($p < 0.05$) higher mean weight of seed tubers (343.00 g) than the first stem-cutting period (320.66 g).

There were significant ($p < 0.05$) interactions between variety X method and variety X stem cutting periods on the mean weight of seed tubers formed (Table 7).

The interaction of variety X method of propagation on the mean fresh weight of seed tubers produced is presented in Table 8. Variety Caruso had the highest fresh weight of seed tubers (588.67 g) produced in the conventional method of propagation, while, variety Nicola produced the highest fresh weight of seed tubers (416.17 g) in the stem cutting method of propagation (Table 8).

The interaction of variety X stem cutting period on the mean fresh weight of seed tubers produced is presented in Table 9. Variety Nicola had the highest mean fresh weight of seed tubers (388.33 g) in the first stem-cutting period, while, variety Lady Christl had the highest fresh weight of seed tubers (474.67 g) in the second cutting period (Table 9).

Discussion

The results obtained from the research study showed that variety and stem-cutting period had a significant ($p < 0.05$) effect on the mean establishment of seedlings from stem cuttings. This cultivar variation could be due to genetic differences in rooting ability. A study [30] reported varieties significantly affecting the rooting of potato cuttings. The significant effect of the stem-cutting period could be due to the age of the mother plant when the cuttings were made. It was observed [31] that the age of mother plants determines the maturity of the stem from which the cuttings were taken. It was suggested [32] that juvenile cuttings have been shown to root better than matured cuttings possibly due to an increase in lignification in older cuttings and the production of rooting inhibitors as stem age is increased.

The plant height was significantly ($p < 0.05$) affected by variety. It could possibly be due to the varietal response to sunlight and the root's response to nutrients. It was reported [27] that the length of the cutting is correlated with the endogenous reserves (e.g. carbohydrate) to support early growth of the cuttings. It was reported [30] that potato plant height depends on its genetic origin. The stem cutting period had a significant ($p < 0.05$) effect on mean plant height at 2 weeks after cuttings were made but not different at 4 weeks after cuttings were made. This could be due to the vegetative stage of the mother plant from which cuttings were made and the rate of aeration. It has been suggested [33] that a higher aeration volume of roots results in an increase in stem length. A study reported [27] that the increase in root aeration results in higher stem growth. It was also reported [31] that cuttings derived from 2- and 3-week-old plants had faster root initiation and shoot elongation.

Variety had a significant ($p < 0.05$) effect on mean number of leaves produced by stem cuttings at both 2 and 4 weeks after cuttings were made. This could be due to genetic variability between the varieties used. It was reported [34] that plant height and number of leaves are highly related to hormonal balance and growth regulators among potato varieties. It has been suggested [35] that the higher photosynthetic rate among potatoes is due to the chlorophyll content of the leaves. The stem cutting period had a significant ($p < 0.05$) effect on the mean number of leaves produced at 2 weeks after cuttings were made. However, at 4 weeks after cuttings were made both the first and second cutting periods were similar. It could be due to cutting size. As reported [27], the cuttings' size affects the growth and canopy of cuttings. The bigger the size of the cutting, the more the endogenous reserves and faster cell division.

The total number of tubers formed was significantly ($p < 0.05$) affected by variety. It could be due to climatic conditions during the growth of cuttings. It was reported [36] that high-temperature stresses during tuberization cause a reduction in number of tubers by up to 50%. A report [37] suggested that the total number of tubers is higher in plants obtained from cuttings than conventional seed propagation. The methods used had a significant effect on total number of tubers formed. This could be due to a higher number of cuttings obtained. It was reported [26] that a higher number of stems was obtained from cuttings, resulting in a higher number of tubers. As reported [17], stem cuttings provide a higher multiplication ratio than conventional propagation.

The total number of ware (sellable tubers) tubers formed was significantly ($p < 0.05$) affected by variety. It could be due to the day length effect and multiplication cycles of cuttings. As reported [38], the tuber size of potatoes is influenced by nitrogen, cultivar, and climatic conditions. It has been reported [39] that the number of multiplication cycles of stem cuttings gets marketable quantity tubers. Methods significantly affected the total number of ware tubers formed. This could be due to the propagation method used. It was reported [40] that conventional tuber propagation results in bigger tuber size than tubers from cuttings. As reported [26], the proportion of marketable tubers was less in crops from conventional propagation than in stem cutting.

Total number of seed tubers formed was significantly ($p < 0.05$) affected by variety. This could be due to differences in stolon number and tuber formation among all types of planting materials. It has been suggested [41] that genetic viability may be responsible for stolon number. Also, it was reported [42] that conventional seed tuber propagation is one of the slowest of seed multiplication. Methods had a significant ($p < 0.05$) effect on the total number of seed tubers formed. This could be due to higher cuttings being raised as seedlings. This was reported [43] with an increase in tuber number, the size reduces, so more seed tubers are produced. Also, it was reported [44] that high stem number increases the number of small-sized tubers preferred by the seed market. Additionally, it was reported [45] that stem cuttings had a higher multiplication ratio than conventional seed propagation.

Conclusion

The study aimed to evaluate seed potato production from stem cuttings and conventional seed tubers.

The varieties used responded differently, Variety Nicola had the highest establishment count of stem cuttings, followed by Caruso, while Lady Christl had the least. However, variety Lady Christl had the highest number of tubers, followed by Nicola, while Caruso had the least number of tubers, this suggests that Caruso had a lower multiplication ratio.

The study showed that Stem cutting method of multiplication produced significantly ($p < 0.05$) a higher mean total number of tubers (84.88) than the conventional seed tuber method (52.77), suggesting that stem cutting is a better alternative to rapidly multiply seed potatoes than conventional seed tuber propagation. Stem cutting produced significantly more seed tubers (78.55) than conventional seed tuber propagation (46.88). It is therefore recommended that the use of stem cuttings as a tool for rapid seed multiplication of potatoes should be adapted to aid in the production of seed potato tubers in countries where plant tissue culture facilities are not available. The use of stem cuttings to propagate potatoes will reduce the cost of production of potatoes.

Limitations of the study and suggestions of areas for future research

Limitations of the study: First, the experiment was potted and was not tried in the open field, second, growth hormones were not used to enhance the rooting of cuttings, growth, and development of the plants, lastly, growth media (substrates) was not varied to determine which one will enhance rooting and establishment of stem cuttings.

Therefore, further research is suggested to evaluate seed potato multiplication using stem cuttings in the open field. Research should also be carried out to evaluate the effect of different growth hormones on the rooting and establishment of potato stem cuttings. Also, further research should be carried out to evaluate the effect of different growth media on the rooting and establishment of potato stem cuttings.

References

1. Gautam U, Poudel S, Rajbhandari BP. The impact of potato-based cropping system on livelihood and income generation at Tamankhola rural municipality, Baglung. Nepalese J Agric Sci. 2021;20:108-114. Available from: https://www.cabidigitallibrary.org/doi/pdf/10.5555/20210130941
2. FAOSTAT (Food and Agriculture Organization of the United Nations). STATISTICS STATISTICAL YEARBOOK. 2021.
3. Agrawal S, Kumar A, Gupta Y, Trivedi A. Potato Biofortification: A Systematic Literature Review on Biotechnological Innovations of Potato for Enhanced Nutrition. Horticulturae. 2024;10(3):292-308. Available from: https://doi.org/10.3390/horticulturae10030292
4. Stewart D, Taylor M. Potato: A Basis for Human Nutrition and Health Benefits. AHDB Potatoes: Kenilworth, UK. 2017;1–60.
5. Mijena GM, Gedebo A, Beshir HM, Haile A. Ensuring food security of smallholder farmers through improving productivity and nutrition of potato. J Agric Food Res. 2022;10040. Available from: https://doi.org/10.1016/j.jafr.2022.100400
6. Wauters P, Naziri D, Turinawe A, Akello R, Parker ML. Economic analysis of alternative ware potato storage technologies in Uganda. Am J Potato Res. 2022;98:217–228. Available from: http://dx.doi.org/10.1007/s12230-022-09874-3
7. Degebasa AC. Review of potato research and development in Ethiopia: Achievements and future prospects. J Biol Agric Healthcare. 2019;9(19):27-36. Available from: http://dx.doi.org/10.7176/JBAH/9-19-04
8. Tafesse S, Braam C, Mierlo BV, Lemaga B, Struik PC. Association between soil acidity and bacterial wilt occurrence in potato production in Ethiopia. Agronomy. 2021;11(1541). Available from: https://doi.org/10.3390/agronomy11081541
9. Woldeselassie A, Dechassa N, Alemayehu Y, Tana T, Bedadi B. Soil and water management practices as a strategy to cope with climate change effects in smallholder potato production in the eastern highlands of Ethiopia. Sustainability. 2021;13(6420):1-19. Available from: https://doi.org/10.3390/su13116420
10. Tesfaye M, Tessema L. Empirical review on determinants of improved potato technology adoption in Ethiopia. Res Dev. 2022;3(3):185-191. Available from: https://www.sciencepublishinggroup.com/article/10.11648/j.rd.20220303.17
11. Bradshaw JE. A brief history of the impact of potato genetics on the breeding of tetraploid potato cultivars for tuber propagation. Potato Res. 2022;65:461–501. Available from: https://link.springer.com/article/10.1007/s11540-021-09517-w
12. Gu J, Struik PC, Evers JB, Lertngim N, Lin R, Driever SM. Quantifying differences in plant architectural development between hybrid potato (Solanum tuberosum) plants grown from two types of propagules. Ann Bot. 2024;133(2):365–378. Available from: https://doi.org/10.1093/aob/mcad194
13. Shiwani K, Kumar RM, Rana A, Kumar D, Sharma N, Singh N. Recent advances in potato propagation. In: Recent trends in propagation of forest and horticultural crops. New Delhi, India: Taran Publication; 2021;225–262. Available from: https://www.researchgate.net/publication/355393915_Recent_advances_in_potato_propagation
14. Endale G, Gebremedhin W, Lemaga B. Potato seed management. In: Root and tuber crops: The untapped resources. Ethiopia Institute of Agricultural Research; 2008;53–78.
15. Muthoni J, Kabira J. Multiplication of seed potatoes in a conventional potato breeding programme: A case of Kenya's national potato programme. Aust J Crop Sci. 2014;8(8):1195–1199. Available from: https://search.informit.org/doi/abs/10.3316/INFORMIT.611953858667670
16. Van Minh T, Van Uyen N, Vander Zaag P. The potato (Solanum spp) production using apical cuttings and tuberlets under three contrasting environments. Am Potato J. 1990;67(11):779–787. Available from: https://link.springer.com/article/10.1007/BF03044529
17. Badoni A, Chauhan JS. Conventional vis-à-vis biotechnological methods of propagation. In: Potato: A review. Stem Cell. 2010;1(10):1–6. Available from: https://www.sciencepub.net/stem/stem0101/01_0763_Anoop_Badoni_stem0101_1_6.pdf
18. Awati R, Bhattacharya A, Char B. Rapid multiplication technique for production of high-quality seed potato (Solanum tuberosum L.) tubers. J Appl Biol Biotechnol. 2019;7(01):001–005. Available from: https://jabonline.in/admin/php/uploads/342_pdf.pdf
19. Zarzyńska K, Trawczyński C, Pietraszko M. Environmental and agronomical factors limiting differences in potato yielding between organic and conventional production systems. Agriculture. 2023;13(4):901–911. Available from: https://doi.org/10.3390/agriculture13040901
20. Singh RK, Buckseth T, Tiwari JK, Sharma A. Seed potato (Solanum tuberosum) production systems in India: A chronological outlook. Indian J Agric Sci. 2019;89(4):578–587. Available from: https://epubs.icar.org.in/index.php/IJAgS/article/view/88839
21. Muthoni J, Shimelis H, Mashilo J. Production and availability of good quality seed potatoes in the East African region: A review. Aust J Crop Sci. 2022;16(7):907–915. Available from: https://search.informit.org/doi/abs/10.3316/informit.726326184586551
22. Abdalla N, El-ramady H, Seliem MK, El-mahrouk ME, Taha N, Bayoumi Y, et al. An academic and technical overview on plant micropropagation challenges. Horticulturae. 2022;8(8):677. Available from: https://doi.org/10.3390/horticulturae8080677
23. Abrar T, Temam HZ, Redwan W. Current status and opportunities of plant tissue culture in Ethiopia. Int J Chem Biomol Sci. 2019;5(1):19–28. Available from: https://www.researchgate.net/publication/331563152_Current_Status_and_Opportunities_of_Plant_Tissue_Culture_in_Ethiopia
24. Obedi NI. Production of potato quality seeds in mountainous region of Central Africa. Adv Root Vegetables Res. 2022;10(5772). Available from: https://www.intechopen.com/chapters/84002
25. Dahshan AMA, Zaki-Yasser EM, Moustafa-Yousry MM, Abdel-Mageed Mohamed T, Hassan AM. Using stem tip cuttings in potato production. Minia J Agric Res Dev. 2018;38(2):363–389. Available from: https://www.researchgate.net/publication/329371871_USING_STEM_TIP_CUTTINGS_IN_POTATO_PRODUCTION
26. Ezzat AL. Effect of some treatments on improving seed multiplication ratio in potato by stem cutting. J Plant Prod Mansouri Univ. 2016;7(7):683–693. Available from: https://jpp.journals.ekb.eg/article_46138_ad0d3d1092d0a70bb40d7e9cdf5580d5.pdf
27. Nikmatullah A, Ramadhan I, Sorjan M. Growth and yield of apical derived stem cuttings of white potato (Solanum tuberosum L.) derived from disease-free seed tubers. J Horticult. 2018;20(2):139–145. Available from: https://horticultureresearch.net/jah/2018_20_2_139_145.PDF
28. Bryan JE, Jackson MT, Melendez NG. Stem cuttings, a rapid multiplication technique for potatoes. Lima, Peru: International Potato Centre; 1981;22.
29. Gomez KA, Gomez AA. Statistical procedures for agricultural research. 2nd ed. New York: John Wiley & Sons; 1984. 680 p. Available from: https://www.scirp.org/reference/ReferencesPapers?ReferenceID=2253909
30. Nuwagira F, Mukasa SB, Wagoire WW, Namugga P, Kashaija IN, Barekye A. Determination of hormonal combination for increased multiplication of tissue culture potato plantlets. Uganda J Agric Sci. 2015;16(1):129–137. Available from: http://journal.naro.go.ug/index.php/ujas/article/view/405
31. Rasmussen A, Hosseini SA, Hajirezaei MR, Druege U, Geelan D. Adventitious rooting declines with the vegetative switch and involves a changed auxin homeostasis. J Exp Bot. 2015;66(5):1437–1452. Available from: https://doi.org/10.1093/jxb/eru499

32. Milborrow BV. Inhibitors. Adv Plant Physiol. 1994;5(12):224–229.

33. Li Y, Niu W, Cao X, Wang J, Zhang M, Duan X, et al. Effects of soil aeration on root morphology and photosynthetic characteristics of potted tomato plants of different NaCl salinity levels. Plant Biol. 2019;19:331. Available from: https://doi.org/10.1186/s12870-019-1927-3

34. Bhatia AA, Pandita ML, Khurana SC, Shekhawat KM, Pandey SK, Chandla VK. Effect of plant growth substances and stem cuttings on growth, yield, and multiplication rate in seed potato production. Potato Present Future. 2010;1(3):285–290. Available from: http://dx.doi.org/10.3329/sja.v15i1.33161

35. Farran I, Mingo-Castel A. Potato minituber production using aeroponics: Effect of plant density and harvesting intervals. Am J Potato Res. 2006; 83(1):47–53. Available from: http://dx.doi.org/10.1007/BF02869609

36. Rykaczewska LT. Comparative analysis of plant development, yield, and photosynthates productivity of the very early potato cultivars. Ruta and Karatop. 2004;1:67–71.

37. Sadawarti MJ, Somani AK, Singh YP, Pandey KK. Comparison of crops raised with tissue culture vs conventional seed tubers of potato. Seed Res. 2013;41(2):170–175. Available from: https://epubs.icar.org.in/index.php/SR/article/view/163632

38. Arsenault WJ, Leblanc DA, Tai GCC, Boswell P. Effect of nitrogen application and seed piece spacing on yield and tuber size distribution in eight potato cultivars. Am J Potato Res. 2001;78:301–309. Available from: https://link.springer.com/article/10.1007/BF02875695

39. Hossain MJ, Vecchio B. Potential of sprout cutting on growth, yield, and multiplication rate of potato. Ital J Agron. 2010;3(1):1–6. Available from: https://www.scirp.org/%28S%28351jmbntv-nsjt1aadkposzje%29%29/reference/referencespapers?reference id=562872

40. Jones ED. Progress in seed production technology. Am Potato J. 1991;68: 247–248. Available from: https://link.springer.com/article/10.1007/BF02853642

41. Tsoka O, Demo AB, Nyende AB, Gamau K. Potato seed tuber production from in vitro and apical stem cutting under aeroponic system. Afr J Biotechnol. 2012;11(63):12612–12618. Available from: https://academicjournals.org/journal/AJB/article-full-text-pdf/59DAAF329473

42. Otazu V. Quality seed potato production using aeroponics. A potato production manual. Lima: International Potato Center; 2008;25.

43. Rex BL. Effect of seed piece population on the yield and processing quality of Russet Burbank potatoes. J Potato Res. 1990;67(8):437–489. Available from: https://colab.ws/articles/10.1007%2Fbf03045110

44. Shayanowako A, Mangani R, Mtaita T, Mazarura U. Influence of main stem density on Irish potato growth and yield. Annu Res Rev Biol. 2015;5(3):229–237. Available from: https://doi.org/10.9734/ARRB/2015/9973

45. Muthoni J, Hussein S, Rob M. Alleviating potato seed tuber shortage in developing countries: Potential of true potato seeds. Aust J Crop Sci. 2013;7(12):1946–1954. Available from: https://www.researchgate.net/publication/257355429_Alleviating_potato_seed_tuber_shortage_in_developing_countries_Potential_of_true_potato_seeds