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PRODUCTION OF SEED TUBERS FROM TRUE POTATO SEED IN JOS- PLATEAU, NIGERIA

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ABSTRACT

An experiment was carried out to evaluate the growth of seedling tubers produced from true potato seed (TPS) for selection of superior clones to produce seed tubers in Jos, Plateau State, Nigeria. A completely randomised design (CRD) was used. The treatment consisted of 15 seed tuber clones produced from TPS and replicated 3 times; each replicate consisted of five plant stands. The parameters assessed included establishment rate, number of above-ground stems per plant, number of leaves per plant, mean plant height, mean number of tubers, mean tuber weight and dry matter content. Generally, the clones varied significantly in all the vegetative and yield parameters assessed. Clones 1, 2, 3, 5, 6 and 11 had a significantly higher number of tubers than clone 10. Clone 1 had the highest mean tuber weight while clone 4 had the least. Clone 10 which had the lowest number of tubers resulted in the highest dry matter. It is concluded that clones 1,2,3,5,6,7 and 11 can be selected for high multiplication ratio, yield and dry matter content.

Key words: Botanical seeds; seedling tubers; clonal selection
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INTRODUCTION

The Potato (*Solanum tuberosum* L.) belongs to the nightshade family Solanaceae (Sumen *et al.*, 2013). Potato is one of the most important food crops in the world. It ranks fourth after wheat, maize and rice (FAO, 2011). Potato is a rich source of starch, vitamins C and B and minerals. It contains about 20.6 % carbohydrate, 2.1% protein, 0.3 % fat, 1.1 % crude fibre and 0.9 % ash (Kumar *et al*., 2011). It also contains a good amount of essential amino acids like *leucine*, tryptophane and isolucine (Kumar *et al*., 2012).

Bradshaw (2022) noted that potatoes naturally reproduce by both sexual and asexual means. Sexual reproduction involves the natural pollination of potato flowers by insects, resulting in true potato seeds (TPS) or botanical seeds in berries (Muchiri *et al*., 2014). Asexual reproduction is by means of tubers also known as seed tubers. When botanical seeds (TPS) are planted, the genetically unique seedlings that arise from these seeds produce tubers which can sprout and grow into new potato plants, giving rise to a complicated mixed sexual or clonal system of reproduction (Bradshaw, 2022).

Potato cultivar development involves a number of steps: first, potato breeders create new variations by generating true seed from natural or open-pollination or by performing directed crosses by transfer of pollen from one parental line to another, to produce true potato seed (TPS) (Mihovilovich *et al*. (2017). TPS is planted to produce seedling tubers, each of which is a unique genotype. The seedling tubers can be re-planted as vegetative tuber seed, thereby establishing clones which are maintained and propagated asexually or vegetatively (Mihovilovich *et al*., 2017). Clonal selection is used to identify clones for varietal selection with appropriate combinations of genes for adaptation and consumers' preference.

Potato breeding activities for selection are mainly concentrated on developing cultivars for processing and table or fresh markets. Processing potatoes are used to produce chips, French fries and dehydrated products. Table or fresh market types are further grouped into reds, russets, whites, purples and yellows (based on skin or flesh colour). The market group with specific morphological traits include tuber shape, eye depth, degree of russeting, tuber number, tuber weight, skin and flesh colour (Stark *et al*., 2020). Tuber shape is extremely important. Chen *et al*. (2018) noted that chips are made with round tubers, while French fries are made with oblong to long tubers. The irregular potato shape with deep eyes results in economic loss due to peeling losses (Li *et al.*, 2005; Sliwka *et al*., 2008).

Seed is one of the most important inputs in potato cultivation. Potato production system based on seed tubers has several disadvantages such as low multiplication rate, high storage and transportation cost, spread of diseases from the parent plant to the offspring, as well as attack by pests and diseases (Dubey *et al*., 2012). Potato crop field faces the danger of being completely wiped out, quick degeneration by viruses and soil-borne diseases True potato seed (TPS) is a cost-effective propagating method that farmers can use to generate healthy planting material in desired quantities due to low ability to transmit pathogens, high multiplication rate and high tuber yield (Pallais, 1994). This study was carried out to evaluate the growth of seedling tubers produced from true potato seed and to select superior clones for the production of seed tubers.

MATERIALS AND METHODS

The study was carried out between the months of May and December, 2019 at Ritdun Integrated Farm Resources, Kangang Road, off Miango Road, near the Jos Wild Life Park (Latitude 09°85'N and Longitude 08°86'E) and at an altitude of 1319 metres above sea level.

Source of Material

Fifteen clones of potato were selected based on visual observation from seed tuber clones produced from TPS (Table 1).

Table 1: Selected potato clones produced from True Potato Seed

Clone	Shape
Clone 1	Elongated
Clone 2	Long-oblong
Clone 3	Long-oblong
Clone 4	Round
Clone 5	Compressed
Clone 6	Compressed
Clone 7	Long-oblong
Clone 8	Obovoid
Clone 9	Obovoid
Clone 10	Elongated
Clone 11	Obovoid
Clone 12	Long-oblong
Clone 13	Oblong
Clone 14	Obovoid
Clone 15	Long-oblong

Experimental Design

A completely randomised design (CRD) was used. The treatment consisted of 15 seed tuber clones produced from TPS which were replicated 3 times. Each replicate consisted of five plant stands.

Cultural Practice

Soil preparation was done on February 5, 2020. A mixture of top-soil and decomposed cowdung in the ratio 3:1 was steam-sterilised at 80° C for 30 minutes to kill weed seeds and pathogenic micro-organisms. The sterilised soil mixture was filled into polyethylene pots which were arranged in an intra-row spacing of 0.3 m and inter-row spacing of 0.3 m. Fully sprouted seed tubers were used and one seed tuber was planted in each polyethylene pot filled with soil mixture on February 6, 2020. Weeding was done by hand-picking as required.

Field Observation
The parameters assessed include emergence and establishment counts at two and four weeks after planting, number of above-ground stems per plant, number of leaves per plant, number of branches per plant and plant height. At harvest, the number of tubers per plant, and mean weight of tubers were assessed.

A sub-sample of twenty (20) grammes of tubers was taken from the harvested tubers in each clone, shredded and dried in a moisture-extraction oven at 100ºC for 24 hours. Dry matter content was computed as the ratio of dry weight of the sample to the sample fresh weight and multiplying by 100 (Mostofa *et al*., 2019).

$$DM\% = \frac{b}{a} \times 100$$

Where,
a = Sample fresh weight
b = Sample dry weight

Data Analysis
Data collected were subjected to one-way analysis of variance (ANOVA), using the Statistical Analysis Software (SAS, version 9.0). Means were separated using least significant difference (LSD) at 5% level of probability.

RESULTS

Emergence and Establishment Rates
Table 2 shows the emergence and establishment of seed tubers produced from true potato seed (TPS). Emergence and establishment of seed tubers were significantly ($p<0.05$) affected by the different clones at 2 and 4 weeks after planting (WAP). At 2 WAP, clone 1 had the highest establishment rate (98.1%) while clone 9 had the least (24.1%) (Table 2). At 4 WAP, clones 1, 2, 3, 4, 7, 9, 12 and 13 resulted in 100% establishment count while clone 10 had the least (69.2%) (Table 2).

Table 2: Establishment rate of seed tubers produced from TPS

	Emergence and establishment rates (%)	
Clone	2 WAP	4 WAP
Clone 1	98.10a	100.00a
Clone 2	85.20f	100.00a
Clone 3	90.60d	100.00a
Clone 4	81.00g	100.00a
Clone 5	95.80b	95.80d
Clone 6	97.40a	97.40b
Clone 7	77.00i	100.00a
Clone 8	86.90e	94.20e
Clone 9	24.10l	100.00a
Clone 10	69.20k	69.20k
Clone 11	79.20h	95.80d
Clone 12	88.00e	100.00a
Clone 13	69.20k	100.00a
Clone 14	94.10c	96.80c
Clone 15	74.00j	94.10e
LS	*	*
$LSD_{0.05}$	1.19	0.19

LS = Level of Significance
LSD = Least Significant Difference

Number of Above-ground Stems per plant

The mean number of above-ground per plant is shown in Table 3. The number of above-ground stems per plant was significantly ($p<0.01$) affected by the clones at all the sampling dates. At 4 WAP, clone 1 produced the highest mean number of above-ground stems (2.33) while clones 3, 4, 5, 6, 7, 8, 9, 10, 13, 14 and 15 had the lowest mean number of above-ground stems. A similar result was obtained at 6 WAP. At 8 WAP, clone 5 produced the highest number of above-ground stems (3.22), while clones 4 and 10 had the least (1.00). At 10 WAP, clone 6 had the highest mean number of above-ground stems while clone 10 had the least (1.00). At 12 WAP, clone 12 had the highest mean number of above-ground stems (4.44) while clone 9 had the least (1.22).

Table 3: Mean number of above-ground stems at different weeks after planting seed tubers produced from TPS

Clone	Number of above-ground stems per plant				
	4WAP	6 WAP	8 WAP	10WAP	12WAP
Variety					
Clone 1	2.33a	2.33a	2.44c	2.55c	4.11ab
Clone 2	1.33b	1.33b	2.39c	2.45d	2.33c
Clone 3	1.00c	1.00d	1.67d	2.00e	1.83d
Clone 4	1.00c	1.00d	1.00f	1.11j	1.33ef
Clone 5	1.00c	1.11cd	3.22a	2.89b	3.78b
Clone 6	1.00c	1.00d	2.89ab	3.22a	2.55c
Clone 7	1.00c	1.00d	1.55d	1.33i	1.89d
Clone 8	1.00c	1.11cd	1.56d	1.44h	2.00d
Clone 9	1.00c	1.00d	1.11ef	1.11j	1.22f
Clone 10	1.00c	1.00d	1.00f	1.00k	2.00d
Clone 11	1.22bc	1.33bc	2.55bc	2.56c	2.22cd
Clone 12	1.22bc	1.45b	2.78bc	2.89b	4.44a
Clone 13	1.00c	1.00d	1.33de	1.33i	2.33cf
Clone 14	1.11c	1.11cd	1.45de	1.78g	1.33ef
Clone 15	1.00c	1.00d	1.44de	1.89f	1.67de
LS	**	**	**	**	**
$LSD_{0.05}$	0.15	0.14	0.35	0.05	0.41

LS = Level of Significance
LSD = Least Significant Difference

Plant Height

Table 4 shows the mean plant height at different weeks after planting of seed tubers produced from True Potato Seed. The mean plant height differed significantly ($p<0.05$) at all sampling dates (Table 4). At 4 WAP, clone 10 had the highest plant height (31.00 cm) while clone 9 had the least (8.64 cm). At 6 WAP, clone 10 had the highest plant height (47.75 cm) while clones 1 and 11 had the least. At 8 WAP, clones 3, 5, 10 and 13 had the highest plant height while clone 1 had the least. At 10 and 12 WAP, clone 13 had the highest plant height (83.33 cm and 89.67 cm, respectively) while clone 1 had the least (36.38 and 35.02 cm, respectively) and the difference was significant.

Table 4: Plant height of plants grown from seed tubers produced from TPS at different weeks after planting

Clone	Plant Height (cm)				
	Weeks After Planting				
	4	6	8	10	12
Clone 1	20.70cd	22.86e	33.27e	36.38e	35.02e
Clone 2	24.59bc	36.89bc	57.94bc	59.79cd	58.04d
Clone 3	23.33bc	40.75b	68.53a	76.60ab	79.13b
Clone 4	18.51d	37.14bc	59.12bc	67.20bc	74.30bc
Clone 5	25.47b	43.28ab	70.84a	81.86ab	90.92a
Clone 6	21.03c	38.41bc	63.72b	73.38bc	72.21bc
Clone 7	17.95d	32.11c	54.89c	61.54cd	64.05c
Clone 8	21.92c	36.56bc	61.88bc	74.41b	75.61bc
Clone 9	8.64f	26.51d	55.16c	68.13bc	75.23bc
Clone 10	31.00a	47.75a	70.15a	75.85ab	72.00bc
Clone 11	14.39e	24.50e	49.80cd	57.96d	58.13d
Clone 12	20.91cd	34.72c	55.94c	67.01bc	74.31bc
Clone 13	22.33c	39.17bc	71.50a	83.33a	89.67a
Clone 14	22.33c	34.33cd	57.64bc	65.82c	68.22c
Clone 15	17.81d	29.67d	47.98d	54.94d	54.73d
LS	*	*	*	*	*
$LSD_{0.05}$	2.67	5.03	6.82	7.72	8.53

LS = Level of Significance
LSD = Least Significant Difference

Number of Leaves per Plant

Table 5 shows the mean number of leaves per plant grown from seed tubers produced from TPS at different weeks after planting. Generally, the number of leaves increased with crop age from 4 WAP to 12 WAP. The mean number of leaves per plant differed significantly ($p<0.05$) at all sampling dates (Table 5). At 4 WAP, clone 1 had the highest number of leaves (35.33) while clone 9 had the least (6.67). At 6 WAP, clone 1 had the highest mean number of leaves while clones 4 and 13 had the least. At 8 WAP, clone 10 had the highest mean number of leaves (73.00) while clone 9 had the least (25.11). At 10 WAP, clones 12, 1 and 10 produce the highest mean number of leaves of 85.11, 80.45 and 80.00, respectively while clone 9 had the least (32.89). At 12 WAP, clone 12 had the highest mean number of leaves (113.33) while clone 9 had the least (46.33).

Table 5: Number of leaves per plant grown from seed tubers produced from TPS

Clone	Number of leaves per plaant				
	Weeks after Planting				
	4	6	8	10	12
Clone 1	35.33a	33.78a	67.78ab	80.45a	85.22bc
Clone 2	20.44b	24.56cd	63.95bc	69.45b	75.56cd
Clone 3	17.00cd	21.67d	48.50e	53.17c	72.17d
Clone 4	11.00e	14.33e	28.89hi	33.44e	49.22e
Clone 5	13.89de	19.56d	57.22cd	68.44b	93.33b
Clone 6	14.00d	16.44e	43.34ef	52.11cd	47.11ef
Clone 7	10.33e	15.89e	32.00hi	44.44d	47.11ef
Clone 8	10.22e	15.11e	34.33gh	49.11cd	56.33e
Clone 9	6.67f	11.00e	25.11i	32.89e	46.33f
Clone 10	14.60d	23.00cd	73.00a	80.00a	79.50cd
Clone 11	14.56d	19.67d	44.22ef	51.78cd	47.89ef
Clone 12	14.56d	27.11c	59.00c	85.11a	113.33a
Clone 13	10.67e	14.00e	29.67hi	41.67de	83.00c
Clone 14	19.56bc	30.78b	55.44d	70.44b	66.99d
Clone 15	12.72de	17.66de	39.78fg	53.00c	74.44cd
LS	**	**	**	**	**
$LSD_{0.05}$	3.01	3.05	7.36	8.39	9.98

LS = Level of Significance
LSD = Least Significant Difference

Number of Branches per Plant

Table 6 shows the mean number of branches per plant grown from seed tubers produced from TPS at different weeks after planting. The mean number of branches differed significantly ($p<0.05$) at all the sampling dates. At 8 WAP, clones 2 and 10 had the highest number of branches (7.00 and 6.28, respectively) while clone 9 produced the least (1.94). At 10 WAP, clones 1, 10 and 12 produced the highest mean number of branches of 8.11, 7.50, and 7.33, respectively while clone 9 produced the least (2.11). At 12 WAP, clone 12 produced the highest mean number of branches (10.67) while clone 9 produced the least (4.06).

Table 6: Mean Number of branches per plant produced from seedling tubers at different weeks after planting

Clone	Number of Branches		
	Weeks after Planting		
	8	10	12
Clone 1	6.11b	8.11a	7.44cd
Clone 2	6.28a	7.11ab	7.11de
Clone 3	3.83d	4.50cd	8.72bc
Clone 4	2.88e	3.78d	4.44g
Clone 5	4.78cd	5.56bc	7.67cd
Clone 6	3.22de	3.55d	4.45g
Clone 7	2.94e	4.11cd	5.00fg
Clone 8	3.67de	5.33bc	5.22fg
Clone 9	1.94f	2.11c	4.06g
Clone 10	7.00a	7.50a	9.50ab
Clone 11	4.33cd	4.67cd	6.06cf
Clone 12	5.95b	7.33a	10.67a
Clone 13	2.50ef	5.00c	8.67bc
Clone 14	5.11bc	6.22b	7.22de
Clone 15	4.00cd	5.67bc	9.22b
LS	**	**	**
$LSD_{0.05}$	0.88	1.08	1.37

LS = Level of Significance
LSD = Least Significant Difference

Total Number of Tubers per Plant
Table 7 shows the mean number of tubers at harvest after planting seed tubers produced from TPS. The mean number of tubers varied significantly ($p<0.05$) with the with the potato clones. Clone 6 produced the highest mean number of tubers (11.82) while clone 10 produced the least (2.00).

Mean Weight of Tubers
Table 7 shows the mean weight of tubers at harvest after planting seed tubers produced from TPS. The mean weight of tubers varied significantly ($p<0.05$) with the different clones (Table 7). Clone 1 had the highest mean weight of tubers (28.43 g) while clone 4 had the least (11.93 g).

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Table 7: Number of tubers per plant and mean weight of tubers of plants grown from seed tubers produced from TPS

Clone	Number of tubers per plant	Mean weight of tubers (g)
Clone 1	9.09cd	28.43a
Clone 2	10.22bc	20.14cd
Clone 3	11.00ab	23.67abc
Clone 4	5.32fg	11.93e
Clone 5	8.36d	19.86cd
Clone 6	11.82a	24.83abc
Clone 7	6.78e	27.53ab
Clone 8	5.03gh	22.67bc
Clone 9	5.56ef	18.11d
Clone 10	2.00i	18.50d
Clone 11	8.22d	23.22abc
Clone 12	6.28cf	24.72abc
Clone 13	5.33fg	16.33de
Clone 14	3.95h	21.50cd
Clone 15	4.28gh	22.00bc
LS	**	*
$LSD_{0.05}$	1.24	5.54

LS = Level of Significance
LSD = Least Significant Difference

Dry Matter Content

Table 8 shows the dry matter content of tubers produced produced from TPS. The dry matter content varied with the different clones. Clone 10 had the highest dry matter content of 21.45 % while clone 4 had the least (14.85 %).

Table 8: Mean dry matter content of tubers produced from TPS seedlings

Clone	Dry mater content (%)
Clone 1	14.95
Clone 2	18.10
Clone 3	16.50
Clone 4	14.85
Clone 5	19.15
Clone 6	19.15
Clone 7	18.55
Clone 8	18.85
Clone 9	21.00
Clone 10	21.45
Clone 11	16.85
Clone 12	18.50
Clone 13	17.90
Clone 14	18.35
Clone 15	16.85
Standard error	0.48

DISCUSSION

The results of this study showed that all the clones had similar emergence and establishment rates except clone 9. The increase in emergence rate could be attributed to the fact that the tubers were planted after they had undergone substantial sprouting. Wiersema (1985) observed that the planting of poorly sprouted potato seed resulted in poor crop emergence and vigour. The study showed that clones 12 and 7 had a higher number of above-ground stems of 4.44 and 4.11, respectively while clone 9 had the least (1.22). The variation in the number of above-ground stems among the different clones could be attributed to an increase in the number of tuber eyes and sprouts produced by the seed tubers that were planted. Kushwah and Grewal (1990) used single-eyed seed pieces, resulting in the development of single-stem plants. Deshi *et al*. (2021) reported that the number of above-ground stems per plant varied with genotype. Rashid *et al.* (1990) reported that tubers from true potato seed produced a significantly higher number of stems and better growth than those from standard varieties. The number of stems per plant influences the number and size of tubers at harvest (Nizamuddin *et al.,*2010).

The number of leaves per plant of the selected potato clones varied significantly throughout the sampling periods. There was a linear increase in the number of leaves at the different sampling periods, suggesting that the production of new leaves in the potato takes a long period. This was an indication that the plants experienced healthy growth and development. Clone 12 had the highest mean number of leaves of 113.33 at 12 WAP while clone 9 had the least (46.33). The observed difference in the mean number of leaves amongst clones may be due to genotypic differences. The number of leaves influences the photosynthetic activity which in turn affects the total tuber yield (Khan *et al.,* 2013). Variation in the number of leaves and number of stems have also been reported by Khan *et al.* (2013).

The number of branches per plant varied across the different clones and increased with the crop age. The observed variation in the number of branches in the different clones was likely due to genotypic differences, as has also been reported by Maharijaya *et al*. (2021) and Alveno *et al*. (2022).

Plant height increased with time throughout the sampling periods, indicating that the plants were grown in the environment that promoted healthy growth. There were no significant differences in plant height from 4 to 8 weeks after planting (WAP). The plant height differed significantly amongst the clones at 10 and 12 WAP. The early growth uniformity suggests that the environment provided optimal growth condition for all the clones during this period. The significant differences in plant height at 10 and 12 WAP suggest that variations caused by genotype and environment are expressed in the latter stages of growth in the potato. Deshi *et al*. (2021) reported plant height to vary with genotype. Khan *et al.* (2013) attributed the variation in plant height to the food reserve for early growth of seed tubers and varietal characters and interactions of planting materials and environment.

The number of tubers per plant differed significantly amongst the clones. Clone 6 produced the highest number of tubers per plant (11.82) while clone 10 had the lowest number of tubers per plant of 2. The variation in tuber number amongst the clones may be due to varietal differences and the variation in stem number. The number of stems per plant has been reported to influence the number and size of tubers at harvest (Nizamuddin *et al*., 2010). Subarta *et al*. (1997) reported that the number of stems per plot influenced the number of tubers per plot, total number of stolons and the number of tuberised stolons. Wurr *et al*. (1990) reported that the increase in the number of stems resulted in increased number of tubers. Deshi *et al*. (2021) reported that the number of tubers per plant varied with variety.

The mean weight of tubers differed significantly amongst the clones. Clone 1 had the highest mean weight of tubers of 28.43 g, while clone 4 had the lowest (11.93 g). The difference in tuber weight could be due to genotypic differences. Maharijaya *et al*. (2021) observed that fresh tuber weight varied with variety, ranging from 129.52-719.74 g. Melito *et al*. (2017) reported variability in tuber yield between families as well as between clones. Clones 9 and 10 had the highest dry matter content of 21.45% and 21.00%, respectively, while clone 4 had the lowest (14.85%). The variation in dry matter content amongst the clones suggests that this trait is genotypically influenced. Dry matter content could be used in the choice of clones suitable for processing like French fries. Clones 9 and 10 could be chosen for this purpose. Naeem and Caliskan (2020) analysed 189 potato genotypes and reported tuber dry matter ranged from 15.19% to 34.50%. They noted that dry matter content was an early determinant of tuber quality and that it influenced the final yield of processed tuber products (chips/crisps and French fries). Abbas *et al*. (2011) reported that tuber dry matter content was strongly influenced by the genotype and that it differed significantly with cultivars. Based on the quality features of potato for direct consumption, tubers should contain 18-22% of dry matter and 10-12% of starch, while potato tubers intended for chips should contain 20-22% of dry matter and 14-17% of starch; for crisps, tubers should contain 20-25% of dry matter and 16-20% of starch (Lisinska, 2000; Grudzinska *et al.*, 2016).

Based on agronomic characteristics like tuber number and weight of tubers, clones 2, 3, 5, 6, 7, 8, 11, 12, 14 and 15 may be selected for seed tuber production, due to the high number of tubers and mean weight of tuber. Okonkwo and Chibuzo (2002) recommended the use of some TPS genotypes in Jos-Plateau due to their high tuber yield. Nkongolo *et al*. (2008) reported that 20 accenssions of the potato were selected based on yield and yield components. Sattar *et al*. (2007) reported that plant height and biomass yield contributed directly to tuber yield, and that they were important indices for selection. Clones 1, 2, 3, 5, 10,13, 14 and 15 could be selected based on the production of higher number of leaves. Tesfaye (2013) reported that farmers preferred a variety called "Marachere" because of excellent ground cover, establishment, stem thickness, freedom from foliar and tuber diseases and uniform tuber size.

CONCLUSION AND RECOMMENDATION

Generally, selected clones varied significantly in all the vegetative parameters assessed. They also varied significantly in tuber number, tuber weight and dry matter content. Although clone 1 had very high tuber number, it had extremely low dry matter content. Clone 10 had very high dry matter content but very low tuber number. Those clones that produced high tuber number may be good for seed tuber multiplication while clones with high dry matter content could be selected for processing**.**

Clones 2, 3, 5, 6, 7, 11 and 12 are hereby recommended for the production of seed tubers while clones 2, 5, 6, 7 and 12 are recommended for industrial processing because of their high dry matter content. Further investigation into True Potato Seed (TPS) is recommended for the selection of potato clones with specific characteristics.

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