EFFECTS OF PLANTING SPROUT CUTTINGS FOR THE CONTROL OF POTATO (*SOLANUM TUBEROSUM* (L.) SCHOTT) DISEASES IN PLATEAU STATE

[1*]Pandukur, S. G., [2]Kahya, S. S., [3]Shut, V. M. and [4]Okechalu, O. B.

[1]Department of Science Laboratory Technology, University of Jos, Plateau State, Nigeria [2]National Root Crops Research Institute Umudike, Potato Programme Kuru, P.M.B. 04 Vom, Jos, Plateau State Nigeria
[3&4]Department of Plant Science and Technology, University of Jos, Plateau State, Nigeria.
*Corresponding Email: psgpan1@yahoo.com; Telephone: 08037698677

SUMMARY

Field experiment was carried out during raining season in June – August, 2017 to investigate the effects of planting sprout cuttings for the control of potato (*Solanum tuberosum*) diseases at the Potato Programme of National Root Crops Research Institute, Kuru, Plateau State, Nigeria. Three standard potato cultivars (Roslin-Ruaka, Bertita and Nicola) and three treatments (Healthy tubers, healthy sprouts and diseased sprouts) from the tubers were cut into single buds and planted in an open field in 81 polythene pots using Randomized Complete Block Design replicated thrice. Growth parameters were carried out forth nightly. The result revealed that the treatments differed significantly for the yield parameters studied. The healthy tubers produced more numbers of tubers (271) than the healthy sprouts (199), while the diseased sprout cuttings had the least number of tubers formed (150). There were significant differences among the number of tubers produced by the healthy sprouts, healthy tubers and diseased sprouts. The marketable tubers of the healthy sprouts showed highest mean number of wares (48) followed by the diseased sprouts (40), while the healthy tubers had the least mean number of wares. The healthy sprouts produced highest mean seed tubers (221) than that of the diseased sprouts (164), while the healthy tubers had least number of seeds (119). The mean plant stand count varied significantly between the varieties ($P<0.05$) with Roslin-Ruaka having the highest mean plant stand count at harvest (28.6) followed by Bertita (23.8), while Nicola had the least (19.9).

Keywords: Planting, potato, sprout, cuttings, disease, control, Plateau State

POTATO (*Solanum tuberosum L.*) is an important commercial crop grown globally (12, 24). It is an important and fast-expanding tuber crop in Nigeria with higher efficiency for tuber yield and days to maturity (22). In the quest for food and struggle for human survival, potatoes had historically, played important roles due to their high yield per unit area and nutritional value (31, 22). Yields of about 10 - 25 tonnes per hectare have been reported under farmers' practices (22).

Potato is used as a vegetable crop in many countries, and a raw material for various foods, confectioneries and industrial products like dextrose (11). In Nigeria, the crop is cultivated in commercial quantities in mainly two states, Plateau and Taraba. Other States where Potato is grown in pockets include Jigawa, Kaduna, Kano, Yobe, Nasarawa, Adamawa and Zamfara (23).

Remarkable yield loss of potato is attributed to various diseases all over the world. It is reported to be infected by as many as 175 diseases besides several physiological disorders (21). Because efficiency of potato production is very low, tubers cost up to 30 - 40 % more than cassava or yam. These facts help to explain why the Nigerian potato sub-sector is still underdeveloped making it one of the lowest yields in the world with limited value addition (28). Interest at federal institutional level to invest in the sub-sector has been limited so far. Efforts have mainly been made at state level especially, in Plateau State where potato production is omnipresent and therefore, significantly contributes to economic growth and improvement of the welfare of poor households (28). Despite all existing challenges, encouraging signals arise from the demand side. However, there still exist numerous challenges that hinder the value chain actors to fully exploit the full potentials of the crop. Main challenges and opportunities at production level include the incidence of late blight, a widespread and an important disease contributing to low yields, high harvest losses and poor quality of farmer - saved seeds, as well as, limited production, distribution and use of clean seeds of suitable varieties (28).

Traditionally, potatoes are propagated by the use of vegetative seed tubers (9, 16). Some methods like tissue culture and sprout cuttings require skilled labour and special equipment (1, 3, 14). Struik and Lommen (29) reported that using sprouted seed may be beneficial,

because this might advance the growth of sprouts or stems.
According to Zaag and Vander (32), sprouting simply means to produce new leaves, shoots or buds; it is the emergence of growth. Jones (15) reported that stem cuttings are used in 30 % of North American and 25 % of European rapid multiplication programs for potato. It has been reported that the sprout may be considered as consisting of three zones: the base correspondent to part of the plant which will be underground bearing rudimentary, adventitious roots and stolons, the stem and growth point surrounded by young leaves (6, 4).

Best potato crop is obtained when the tuber is first pre-sprouted before planting (22). Healthy and sprouted tubers are selected to obtain the cuttings, sprouts are plucked and cut to pieces, each with at least a bud (22). Using older or pre-sprouted tubers may be beneficial, because this might increase the number of sprouts per mother tuber (20, 6, 5). If farmers use new methods in potato planting about 18 percent of total edible potato production in developing countries can be saved for food (7). Moreover, Nigerians pay more for potatoes than for any other staple crops. It was recorded that in Bangladesh sprout cutting techniques proved to be an effective method of seed potato production against potato virus Y (PVY) and potato leaf roll virus (PLRY) (24). Sprout cuttings had also, proved to be effective on the growth yield and multiplication rate of potato (10).

Moreover, such efforts would also be highly sustainable for the production of potato since it might ensure the supply of fungal - free seed potato to the farmers on time. However, the seed potato tubers obtained from sprout cuttings have not yet been properly evaluated against potato diseases especially, in Plateau State. In view of these facts, the present study was undertaken to evaluate the performance of potato growth characteristics and tubers produced from sprout cuttings against Potato leaf blight (PLB) disease.

MATERIALS AND METHODS

Experimental site

This experiment was carried out at National Root Crops Research Institute (NRCRI), Potato Programme Kuru, Vom, geographically situated on latitude of 9^0 44N and longitude of 8^0 47E, Jos Plateau State, Nigeria

Source of the potato seeds

The potato varieties used in the studies which are Roslin-Ruaka (V1), Bertita (V2) and Nicola (V3) were obtained from National Root Crops

Research Institute (NRCRI), Vom, Plateau State. These seeds were kept under Diffused Light Store (DLS) to enhance sprouting.

Soil preparation

Sandy-loam soil was collected and mixed uniformly with cattle dung in ratio 3:1 (3 parts top soil and 1part cattle dung). The prepared soil mixture was filled to a depth of 30 cm in 81 polythene bags and watered afterwards to allow it settle before planting the cultivars. The 81 polythene pots were arranged in 3 rows, each containing 27 pots, after which each potato variety was planted using Randomized Complete Block Design (RCBD).

Sprouting of the seed potatoes

The seed tubers were stored in a diffused light store (DLS) to enhance sprouting. About 2 - 3cm long sprouts from healthy and diseased tubers were cut-off from three standard popular commercial potato cultivars (Roslin-Ruaka (V1), Bertita (V2) and Nicola (V3). Each tuber (diseased and healthy tubers) having sprouts were cut with a sharp sterile blade carefully and separately so that every piece should contain not less than one node on them. The sprout cuttings from healthy tubers (V1-V3) were kept in a plastic basket, away from the sprout cuttings of the diseased tubers in DLS.

Sowing of the seeds

The sprouts and tubers were planted on the 13 June 2017, with one seed per bag having the spacing between bags and plants 8 and 28 cm, respectively using the methods of *Singh et al.* (27) and Wadhwa *et al.* (30). The sprouts and tubers were carefully dipped into the prepared potted soil at comfortable depth and watered. Weeding of the crop was carried out at 6 weeks after planting.

Fertilizer application

Fertilizer application on the field was done two weeks after planting (WAP); in 5 grams per plant according to the method of (2). Nitrogen, Potassium and Phosphorus (NPK 15:15:15) was applied to the soil using ring application method to help enhance the growth and development of the crop. The application was done on the 7th August, 2018.

Data collection and analysis

Data were collected on the establishment count, Number of above ground stems, Number of leaves, Plant height, Plant stands count at harvest, Stem Number at harvest, Total Number and weight of tubers formed, Number and weight of ware tubers and Number of seed tubers after harvest.

Analysis of variance (ANOVA) was used for all the treatments in analyzing the various data collected.

REULTS

Sprouting of the seed potatoes

The seed potatoes stored in the research storage facility at Kuru station produced sprouts. The potato cultivars; Nicola (V3), Bertita (V2) and Roslin-Ruaka (V1) sprouted after two, three and four weeks, respectively. The sprouts developed up to 8 - 12 cm long.

Establishment count

The healthy tubers, healthy sprouts and sprout cuttings from diseased tubers at 2 weeks after planting (WAP) and 4 weeks after planting (WAP) were fully established. The mean establishment count of all the treatments after 2 and 4 weeks are the same (Table 1).

Table 1: Mean establishment count for sprout cuttings and seeds of potatoes at 2 and 4 weeks after planting.

Treatment	Time (weeks)	
	2	4
Healthy sprout	9.0	9.0
Healthy tubers	9.0	9.0
Diseased sprouts	8.7	8.7
Total	26.7	26.7

Mean number of above ground stems

The results of this investigation revealed that the healthy tubers resulted in higher mean above ground stems (193.3cm) than the healthy sprouts (125cm) while the diseased sprouts had the least mean number of above ground stems (115.6cm) at 5 % level of significance. The number of above ground stems of the healthy tubers and healthy sprouts were significantly higher than the number of above ground stems of the diseased sprouts ($P<0.05$). The highest number of above ground stems was recorded for potato seed at 4 WAP, after which a reduction in number of above ground stems was observed as the plants grew. The three varieties used Roslin - Ruaka (V1), Bertita (V2) and Nicola (V3) did not show any significant differences ($P<0.05$) from each other with respect to the number of above ground stems (Table 2).

Table 2: Mean number of above ground stem at the different weeks after planting

Treatment	Time (weeks)					
	4	6	8	10	12	Total
Healthy sprouts	32.1	26.9	24.6	21.7	19.7	125
Healthy tubers	48.6	47.6	42.4	30.1	24.6	193.3
Diseased sprouts	26.23	25.4	25.7	18.8	19.5	115.63
Mean	29.23	33.3	30.9	23.53	21.27	
LSD	NS	1.53	1.78	0.94	0.86	

Mean plant height

The mean plant height was lower for diseased sprouts (656.2 cm) than the healthy sprouts (686.2 cm), the healthy tubers had the highest (758.8cm) mean plant height. There was significant difference at 5% level of significance for the mean plant heights at the different WAP except, at week 6 which showed no significant difference at 5% level of significance. The three varieties Roslin - Ruaka (V1), Bertita (V2), and Nicola (V3) showed significant difference at 5% level of significance. The mean plant height was higher at 4 WAP, followed by week 10, 8 and 12, while week 6 had the least (Table 3).

Table 3: Mean plant height (cm) at the different weeks after planting.

Treatment	Time (weeks)					
	4	6	8	10	12	Total
Healthy sprouts	175	105.8	134.3	140.4	130.6	686.1
Healthy tubers	234.6	120.2	139.3	143.3	121.4	758.8
Diseased sprouts	152	108.8	127	140.8	127.6	656.2
Mean	187.2	111.6	133.5	143.8	126.51	
LSD	6.84	2.84	2.89	4.01	3.08	

Mean number of leaves per plant

The mean number of leaves per plant was higher for healthy tubers (2176.9) than the healthy sprouts (1743.7), while the diseased sprouts had the least (1636.1) mean number of leaves per plant (Table 4).

The mean number of leaves produced by the diseased sprouts showed significant difference when compared to the number of leaves produced by the healthy sprouts ($P<0.05$). The healthy tubers had significantly higher number of leaves than the healthy sprouts while number of leaves for the diseased sprouts had significant difference at the 0.05 level of probability. At week 10 there was no significant difference in the mean

number leaves among the healthy sprouts, healthy tubers and diseased sprouts. There was increase in the number of leaves in weeks 8 and 12, but this increase was not significant ($P<0.05$) (Table 4). However, there was significant difference in the number of leaves in weeks 4, 6, and 10 at 5% level of probability. The mean number of leaves per plant varied significantly between the varieties used at 5% level of significance (Table 4).

Table 4: Mean number of Leaves at the different weeks after planting

Treatment	Time (weeks)					
	4	6	8	10	12	Total
Healthy sprouts	244.9	390	450.3	383.7	274.8	1743.7
Healthy tubers	460.5	604.4	512	356.5	243.5	2176.9
Diseased sprouts	239.6	368.2	417.4	359.6	251.3	1636.1
Mean	315	371.2	420.4	366.6	256.53	
LSD	11.18	11.65	NS	19.14	NS	

Mean plant stand count at harvest

The result in Table 5 showed that Roslin-Ruaka (VI) recorded the highest plant stand count (14) in healthy tubers at harvest while the least (5.6) was recorded in the diseased sprouts of Nicola (V3) and Roslin-Ruaka (V1). There were significant ($P<0.05$) differences among the treatments (i.e. healthy sprouts, healthy tubers and diseased sprouts) with respect to the mean plant stands at harvest. The highest mean plant stand count of the healthy tubers was (30.4) across the three varieties than the healthy sprouts (22), while the diseased sprouts showed least number of stand count at harvest (19.9) (Table 5).

Table 5: Mean plant stand count at harvest

Variety	Healthy sprouts	Healthy tuber	Diseased sprouts	Total
Roslin-Ruaka (V1)	09	14	5.6	28.6
Bertita (V2)	6.7	8.4	8.7	23.8
Nicola (V3)	6.3	08	5.6	19.9
Total	22	30.4	19.9	72.3
LSD	1.21			

Tuber yield and sizes at harvest

The results on tuber yield showed that the healthy tubers recorded the highest (271) followed by the healthy sprouts (199). Meanwhile, the diseased sprouts produced (150) tubers. The wares produced by the diseased sprouts (40) were insignificant when compared to the healthy sprouts (48) (Table 6). The highest seed tuber was produced by the healthy sprouts (221) followed by the diseased sprouts (164), while the least was produced by the healthy tubers (119) (Table 6).

Table 6: Potato tuber yield after harvest

Treatment	Seed tubers	Ware tubers	Total tubers
Healthy sprout	221	48	199
Healthy tubers	119	36	271
Diseased sprouts	164	40	150
Mean	168	41.33	206.67
LSD	7.26	NS	8.65

Weight of potato tubers after harvest

In Table 7, the highest total potato weight was recorded in healthy tubers (11kg) followed by healthy sprouts (8.5kg), while the lowest was in diseased sprouts (7.9kg); which were also significantly different ($P<0.05$). The highest weight of ware tubers was in healthy sprouts (7.7k) than the diseased sprouts (6.9kg), while the healthy tubers had the lowest significant weight (5.5kg). Meanwhile, the highest weight of the seed tubers was recorded in healthy sprouts (6.8kg) followed by the healthy tubers (5.9kg), while the diseased sprouts had the least (5.3kg) (Table 7).

Table 7: Weight of potato tubers

Treatment	Weight (kg)		
	Seed tubers	Ware tubers	Total tubers
Healthy sprouts	6.8	7.7	8.5
Healthy tubers	5.9	5.5	11
Diseased sprouts	5.3	6.9	7.9
Mean	6.0	6.7	9.13
LSD	0.19	0.39	0.41

DISCUSSION

The results showed that sprout cuttings from both healthy and diseased potato tubers yield significant ware tubers and seeds. This was in line with what was reported by Rahman and Akanda (24) in which a successful attempt in the use of sprout cutting techniques as a way of eliminating potato viruses. He stated that the least incidence of PVY and PLRV was recorded when seed tubers from sprout cutting were used. Whereas, the highest incidence of the viruses was observed where conventional seed tubers were planted. It also showed that Roslin-Ruaka (V1) out yielded the other varieties significantly in growth characteristics. This was followed by Bertita (V2), while Nicola (V3) had the least growth characteristics and yield.

In this study, it was also observed that there was significant difference in certain growth parameters of the different varieties (V1, V2 and V3); these observed differences may be due to the seed types used in cultivation of the potatoes. The result also showed that sprout cuttings from both healthy and diseased potato tubers yield significant ware tubers and seeds which are in line with what was reported by Headford (9) and Ifenkwe and Okonkwo (12) who stated that cut seed tubers may also yield as whole tubers if properly maintained in the field. At 4, 6 and 8 weeks after planting (WAP), the number of above ground stems, number of leaves and plant height were significantly different at the different treatments used. This was also witnessed in the different varieties used in this study.

These varieties are characterized by high yields and a relatively short growth period. However, they are easily affected by diseases in this environment. The most serious diseases effecting varieties planted in the Plateau area include late and early blight (28). Prevailing climate conditions are favorable especially, for the development of late blight that particularly occurs during the rainy season. An insufficient and often inappropriate application of pesticides by farmers further fosters the spread of such diseases (28).

This result is also in agreement with the work of Kim (17) who reported that quality stem cuttings under controlled environment can give high yield and quality after transplanting in the open fields or in the greenhouses. However, there was a significant difference in the interaction between the treatments and the varieties used at 10 WAP. This was evident in the sprouts cutting of both healthy sprouts and diseased sprouts which

yielded high number of leaves, high plant height and a greater number of above ground stems. This was similar to the studies reported by Janick *et al.* (13), Mckeown (19), Rykbost and Locke (25), Hossain and Vecchio (10) and Karim *et al.* (16) that sprout cuttings showed early rooting and new shoots, develop maximum number of longest leaves per plant, number of branches and plant height and forage coverage. They also reported that seed size affects performance of three potato varieties. This was in line with the studies done by Siddique *et al.* (26), Kushwah and Grewal,(18), Rykbost and Locke (25) and El-Helaly (8) which reported that using single eye seed pieces can develop into single stem plants like the sprout cutting plants, resulting in similar number of the weight of tubers per plant.

It was also observed that the performance by diseased sprout cuttings obtained higher number of wares tubers and seed tubers, was in line with what was reported by Headford (9) and Rahman and Akanda (24) who stated that the performance of seed tubers produced from sprout cutting was better in respect to plant growth, tuber number and tuber yield as compared to seed tubers from stem cutting or conventional method. This was also evident in the yield of the sprout cuttings which showed that ware tubers and seed tubers can be obtained from sprouts cuttings for the next season planting. Seed borne diseases spread quickly, and cannot be controlled using chemicals. Use of healthy and disease - free seed tubers following sprout cuttings of potato tubers can help to minimize the seed - borne disease.

Conclusion

This study showed that the diseased sprouts cutting exhibited similar growth and yield characteristics as the healthy sprouts which in turn had similar growth characteristics and yields as the healthy tubers. In addition, the performance of the sprout cuttings was better in respect to plant growth, ware tubers and seed numbers. It also showed that diseased sprouts can produce viable wares, and seeds that may be useful to local farmers of potato in Plateau State having problems with tubers being diseased before the next planting season.

Performance of seed tubers obtained from sprout cuttings was better in respect of growth parameters, yield and yield contributing characters as compared to conventional tubers. Therefore, attempt may be made to produce disease - free seeds by sprout cutting procedure from E-class seeds in a net house. It will be effective to avoid import of E-class seeds from

abroad every year and a huge amount of foreign currency could be saved.

Production of seeds for commercial sales need to be done in a certain scale in order to meet the demands of the buyers and to be able to provide stable supply. When a part of the production is affected by diseases or pests, this must be substituted by seeds produced in other plots; otherwise, the buyers will not be able to rely on the producers for stable supply.

Therefore, the use of sprout cutting techniques as a tool for disease control can be recommended to commercial and smallholder farmers, researchers and stakeholders of potato in Nigeria to cope yield losses due to pathogens and climatic changes, and enhance the production of the crop to mitigate threats to food security.

REFERENCES

1. **Ali, M.S. and Khan, A. L. 1990.** Pathological constraints of seed potato production in Bangladesh. Proceedings of the International Seminar on Seed Potato. January 8-10, held at Dhaka, Bangladesh, 240p.
2. **Batra, V.K., Malik, Y.S. and Pandita, M. L. 1993.** Effect of fertilizer treatments and size of seedling on establishment in relation seedling tuber production in nursery beds. Haryana Agricultural University. *Journal of Research*, 23(2): 77-82.
3. **Benz, J. S., Keller, E. R. and Midmore, D. J. 1995.** Planting materials for warm tropic potato production: growth and yield of transplanted seedlings or rooted cutting and tuber materials in the field. Field Crops Research, 40(3): 179-192.
4. **Bohi, W. H. and Love, S. H. 1999.** Effects of removing seed pieces and planting depth on Potato yield. Potato Conference Idaho, pp20-21.
5. **Bohi, W. H., Love, S. L. and Thompson, A. L. 2001.** Effect of seed piece removal on yield and agronomic characteristics of Russet Burbank Potatoes. *American Journal of Potato Research*, 78(6): 397-402.
6. **Burton, W. G. (1989.** *Propagating by true potato seed: in the potato*. Longman Singapore publishing limited, pp 68-83.
7. **Centro Internacional de la Papa (CIP). 1982.** World Potato Facts. International Potato Center (CIP), Lima-Peru., pp: 54.

8. **El-Helaly, M. A. 2012.** Propagation of Potato (*Solanum tuberosum* L.) by Seedlings. *American-Eurasian J. Agric. & Environ. Sci.*, 12 (9): 1117-1121.
9. **Headford, D. W. R., 1962.** Sprout development and subsequent plant growth. *Eur. Potato J.*, 5: 15-22.
10. **Hossain, J. G. and Vecchio, V. 1999.** Potential of sprout cuttings on the growth, yield and multiplication rate of potatoes. *Bangladash Journal of Agriculture.* 60:1-7.
11. **Hussain, M. M. 1995.** Seed production and storage technology. First edition. 27/1, North Pererbag, Mirpur, Dhaka-1216. 520pp.
12. **Ifenkwe, O. P. and Okonkwo, J. C. 1983.** Use of cut seed for seed production. *Annual report* National Root Crops Research Institute Umudike, Umuahia. Pp 53-60.
13. **Iritani, W. M., Weller, L. D. and Knowles, N. R. 1983.** Relationships between stem numbers, tuber set and yields of Russet Burbank Potatoes. *Am. Potato J.*, 60:423-431.
14. **Janick, J., Schery R. W., Wood D.W., and Rattan V.W 1994.** *Plant Science. An Introduction to World Crops.* Pub. W. H. freeman San Francisco, pp 183.
15. **Jones, E. D. 1988.** A current assessment of *in vitro* culture and other rapid multiplication methods in North America and Europe. *Am. Potato J.*, 65: 209-220.
16. **Karim, M. R., Hanafi, M. M., Shahidullah, S. M., Rahmand, A. H., Akanda, A. M. and Khair, A. 2010.** Virus Free Seed Potato Production through Sprout Cutting Techniques under Net House. *African Journal of Biotechnology* 9 (36):5852-58.
17. **Kim, Y. H. 2008.** Growth characteristics of potato transplants grown under controlled environment. *Acta Horticulturae*, 21: 1093-1098.
18. **Kushwah, V. S., Grewal, J. S. 1990.** Relative Performance of Cut and Whole Seed Tubers for Growth and Yield of Potato (*Solanum tuberosum* L.). *Indian Journal of Agricultural Science*, 60:321-327.
19. **Mckeown, A.W. 1990.** Growth of early Potatoes from different portions of seed tubers II yield. *Am. Potato J.*, 67: 761-768.
20. **Nielson, M., Iritani, W. M. and Wetter, L. D. 1989.** Potato seed productivity: Factors

influencing eye number per seed piece and subsequent performance. Am. Potato J., 66: 151-160.

21. **Okonkwo, J. C. and ifenkwe, O. P. 1988.** Effect of nitrogen phosphorus rates and plant population on total and graded yield of potato (*Solanum tuberosum* L.) in Jos Plateau. *Nigerian Agricultural Journal* 23:pp31-40.
22. **Okonkwo, J. C., Ene, L. S. O. and Okoli, O. O. 1995.** Potato production in Jos Plateau State. National Root Crops Research Institute Umudike, pp 34.
23. **Okunade, S. D. 2004.** Indigenous Knowledge in Irish Potato Preservation, Processing and Utilization: Proceedings of the Seminar on the Indigenous Knowledge in Post-harvest Handling of Roots and Tuber Crops. NSPRI Illorin, pp53-64.
24. **Rahman, M. S. and Akanda, A. M. 2009**. Performance of seed potato produced from sprout cutting, stem cutting and conventional tuber against PVY and PLRV. *Bangladesh Journal of Agriculture.* 34(4):609-622.
25. **Rykbost, K. A. and Locke, K. A. 1999.** Effect of seed piece size on performance of three Potato varieties in the Klamath Basin of Oregon. *Amer. J. Potato Res.*, 76:75-82.
26. **Siddique, M. A., Rabbani, M. G., Azad, M. I. 1987.** Effect of seed size, number of eyes in seed piece and plant spacing on the yield of potato. *Bangladesh Journal of Agriculture* 12:73-81.
27. **Singh, B., Paljor, E. and Jadhav, K. L. 1995.** Effect of plant spacing on yield of potato (*Solanum tuberosum* L.) grown through seedling. *Indian Journal of Agricultural Sciences*, 65(9): 683-685.
28. **Sylvanus, M. A., Michael, K. and Folarin, R. O. 2104.** Promotion of Potato Value Chains in Nigeria. Value link Manual, the Methodology of Value Chain Promotion First edition GTZ. Training Seminar Jos, February 15, 2015.
29. **Struik, P.C. and Lommen, W. J. M. 1999.** Improving the field performance of micro and mini tubers. Potato Research, 42(3/4): 559-568.
30. **Wadhwa, B. K., Pandita, M. L. and Khurana, S. C. 2001.** Performance of potato seedlings rose in different

types of containers and nursery beds, in the field. *Haryana Journal of Horticultural Sciences*, 30 (3/4): 254-257.

31. **Williams, G. G. 1962.** *Potato Growing in Plateau province Samaru.* Agricultural Research Samaru. Zaria. Pp 67-97.

32. **Zaag, D. and Vander, E. 1986.** Potato production in the tropics and subtropics with special reference to Nigeria towards increased potato production in Nigeria. Workshop Papers NRCRI, Vom pp 9-12.