NJB, Volume 36 (2) 115-126, Dec., 2023

EFFECTS OF PLANTING DATE AND GROWTH ENVIRONMENT ON PRODUCTION OF SEED TUBERS FROM TRUE POTATO SEED (TPS)

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Received 26th November, 2023; accepted 29th December, 2023

ABSTRACT

An experiment was carried out to evaluate the effects of planting date and growth environment on the production of potato (*Solanum tuberosum* L.) seed tubers from true potato seed (TPS) in Jos, Plateau State, Nigeria in the year 2019. A completely randomised design was used, consisting of three planting dates (May 10, May 25, June 9, 2019) and three growth environments (shaded field, open field and greenhouse), giving a total of nine treatment combinations in three replicates. Data collected were subjected to analysis of variance using the statistical software SAS, 9.0 version. The means were separated using the least significant difference. The results showed that planting date had significant ($p<0.05$) effect on mean establishment count, number of leaves at all sampling dates except at 104, 118 and 146 days after planting (DAP); plant height at all sampling dates except at 62, 118 and 132 DAP; mean number and weight of tubers at harvest. Growth environment had significant ($p<0.05$) effect on mean number of leaves produced at 132 to 174 DAP; plant height at all sampling dates except at 62 and 132 DAP, mean number and weight of tubers at harvest. Interaction of planting dates and growth environment was significant on mean plant height at 132 to 174 DAP. It is concluded that early planting, shading and open growth environment enhanced seed tuber production from true potato seed.

Key words: Growth environment; planting date; true potato seed (TPS); yield
https://dx.doi.org/10.4314/njbot.v36i2.2

INTRODUCTION

Potato (*Solanum tuberosum* L.) is an important source of food globally and the third most important source of food security crop in the world after rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) (Haverkort *et al*., 2009). Potato is grown for food, animal feed and other industrial uses. It contains high carbohydrate, calcium and potassium and it is a major source of antioxidants (Chen *et al*., 2007).

Potato propagation is mainly done through vegetative method (using clones) and sexually through the use of true potato seed (TPS). Vegetative propagation is a way of multiplying plants using other parts other than seeds. Accantiono and Malagamba (2002) reported that vegetative propagation by tubers has a number of advantages which include early-maturing tubers which look like the mother plant genetically, with a uniform field of crop. In spite of all these advantages, vegetative propagation of potato by tubers has a number of disadvantages, which include easy spread of diseases from the parent plant to the offspring; the field stands the danger of being wiped out completely by diseases as the entire population may be susceptible; more skills and equipment are required in vegetative propagation, which makes it costly (Vreugdenhil, 2007). Potato tubers are bulky, heavy and easily get rotten (Deb *et al*., 2013). About two tons of potato seed tubers may be required to plant one hectare of land which can be replaced with 100 g of TPS (Mahmood, 2005).

Potato propagation using TPS is a captivating and promising technology that farmers can adopt to overcome the constraints associated with clonally propagated tubers (Sadawarti *et al.*, 2018). TPS is a cost-effective propagating material and farmers can use it to generate healthy planting material in desired quantities due to its low ability to transmit pathogen as well as high multiplication rate and high tuber yield (Nath *et al.*, 2017; Rashid *et al.*, 2000).

Appropriate time of sowing is one of the basic requirements for obtaining maximum yield and profit returns of potato (Kar, 2003). Many experiments on sowing and transplanting time have been conducted in different parts of the world, which showed that the total yield of the crop is markedly influenced by different sowing and transplanting times (Braun, 1997; Dehdar *et al*., 2012). Ismatullayev *et al*. (2014) reported that planting dates have a great influence on the growth processes of potato plants, as well as on the duration of the interphase periods. Early planted potatoes form more vegetative yield and good leafed stems, increase in above-ground mass as well as the expansion of leaf surface-area and increased photosynthesis, which contribute to the accumulation of an early harvest of high-quality tubers. Hossian (1997) observed that early planted top-shoot cuttings produced more tubers per plant with a higher mean tuber weight than from the late planting.

In order to maintain good health standards of the early generation of TPS-derived materials, it is better to make use of nurseries or well-controlled environments to produce seedlings and seed tubers (Muthoni *et al*., 2014). Construction of greenhouse is carried out in order to have a controlled environment in agriculture. This is achieved by installation of equipment to monitor and control air temperature, relative humidity, vapour pressure deficit and light levels (Ingeli *et al*., 2015). Greenhouses are intensively used for protection of tender or out-of-season plants from excessive heat or cold conditions in countries such as Israel, United States of America, Australia, India and Turkey. Greenhouses are often used for the cultivation of horticultural crops, vegetables, fruits and flowers and for research protection and isolation of plants from diseases or insects (Mijinyawa *et al*., 2011; Both *et al*., 2015). This study was aimed to determine the effects of planting date and growth environment on production of seed tubers from true potato seed (TPS).

MATERIALS AND METHODS

The experiment was carried out 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 altitude 1,319 metres above sea level between the months of May and December, 2019 under rainfed conditions.

The open-pollinated true potato seeds (TPS) were obtained from the National Root Crops Research Institute, Potato Station, Kuru, Plateau State, Nigeria. The experiment was laid out in a completely randomised design (CRD). The treatments consisted of three planting dates: May10, May 25, June 9, 2019 and three (3) growth environments: shaded field, open field and greenhouse giving a total of 9 treatment combinations in three replicates. Each replicate consisted of three plant stands.

Soil preparation was carried out on May 7, 2019. A mixture of top soil and cow dung in the ratio 3:1 was steam-sterilised to kill weed seeds and pathogenic micro-organisms. The sterilised soil was filled into the plastic seed trays for planting of true potato seed (TPS) nursery. The sterilised soil mixture was filled into polyethylene pots for transplanting of TPS seedlings. A small steel metal was used to pick the TPS seedlings from the seed tray into the polyethylene pots. TPS was planted at an interval of two weeks for each planting date as follows:

Table 1: Different planting and transplanting dates of TPS

Planting date	Designation	Transplanting date
May 10, 2019	Early planting (PD1)	June 2, 2019
May 25, 2019	Mid planting (PD2)	June 15, 2019
June 9, 2019	Late Planting (PD3)	June 29, 2019

The growth environments used consited of:

i. Shaded field used was a round hut, roofed but the sides were open for penetration of sunlight and air
ii. Open field used was an open area, without any covering material
iii. Greenhouse used was locally made using transparent polyethylene covering material

Weeding was carried out by hand-picking when the need arose. An insecticide Lmiforce[R] (Lmiclaclorid 200 g LSL.) 1.25 ml was mixed with fungicide Red force (Metalaxyl-M% + copper loxide %) at the rate of 4 g in 2 litres of water was evenly spread on the plants on the July 27, 2019 to protect the plants from red spider mite and late blight attack, respectively. Emergence and establishment counts, number of leaves formed per seedling plant at transplanting, height of seedling at transplanting, number of leaves after transplanting, plant height 2-weekly intervals, number of tubers per plant, mean tuber weight and shape of tubers were taken.

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

RESULTS

Establishment Count

Table 2 shows the effect of planting date on germination and establishment of seedlings from true potato seed (TPS) at 2 and 3 weeks after planting. Germination and establishment of TPS were significantly affected by planting date at both 2 and 3 weeks after planting. At 2 weeks after planting, planting dates 1 and 2 had significantly higher establishment count (55.67 and 54.00% respectively) than planting date 3 (50.00%). However, at 3 weeks after planting, planting date 1 resulted in a significantly ($p<0.05$) high mean establishment count (58.00%) than plating dates 2 and 3 (54.33%).

Table 2: Effect of planting date on germination and establishment of True Potato Seed at 2 and 3 weeks after transplanting

	Establishment count (%) Weeks after Planting	
Planting Date	2	3
May 10	55.67a	58.00a
May 25	54.00a	54.33b
June 9	50.00b	54.33b
LS	*	*
$LSD_{0.05}$	3.29	3.20

LS = Level of Significance
LSD= Least Significant Difference

Number of leaves and plant height at transplanting

The number of leaves and the height of seedling plants from TPS at transplanting (21 days after planting) are shown in Table 3. Planting on June 9, 2019 resulted in a significantly ($p<0.05$) higher mean number of leaves at transplanting (4.27) than at the other planting dates (3.23 and 3.43, respectively). Planting on May 25 and June 9 resulted in a significantly ($p<0.05$) higher plant height (2.33 and 2.48m cm, respectively) at transplanting than planting on May 10, 2019 (1.67 cm).

Table 3: Effects of planting pates on mean Number of leaves and plant height at transplanting

Planting date	Number of leaves	Plant height at transplanting
May 10	3.23b	1.67b
May 25	3.43b	2.33a
June 9	4.27 a	2.48a
LS	*	*
$LSD_{0.05}$	0.42	0.40

LS= Level of Significance
LSD= Least Significant Difference

Number of leaves per plant after transplanting

Table 4 shows the effects of planting date and growth environment on mean number of leaves per seedling plant produced from TPS after transplanting. Generally, the number of leaves increased to a maximum and then began to decline. The effect of planting date on mean number of leaves produced after transplanting was significant ($p< 0.05$) at all sampling dates except at 104, 118 and 146 days after planting. At 48 days after planting, planting on May 25 and June 9 resulted in a significantly higher mean number of leaves (9.74 and 8.85, respectively) than planting on May 10 and 25 (7.85). Planting on June 9 resulted in a significantly ($p < 0.05$) higher number of leaves per seedling plant on May 10 and May 25 than planting at 62, 76, 90 and 132 days after planting. All the planting dates resulted in the same mean number of leaves per plant at 104, 118 and 146 days after planting ($p<0.05$) (Table 4).

The effect of growth environment on mean number of leaves per plant after transplanting was significant at 132, 146, 160 and 174 days after planting. Plants grown in the shade produced a significantly ($p<0.05$) higher number of leaves than those grown in the green house at 132, 146, 160 and 174 days after planting (Table 4).

The interaction of planting date and growth environment on mean number of leaves per plant is presented in Table 5. At 146 days after planting (DAP), the plants grown under shade and open field after transplanting on June 9 produced a significantly higher mean number of leaves per plant than those planted on May 10 and May 25, which had a similar number of leaves. The plants planted on May 10 and grown under a greenhouse produce the highest number of leaves, which was followed by those planted on May 25 while those planted on June 9 had the least mean number of leaves per plant ($p<0.05$) (Table 5).

At 160 DAP, the plants planted on May 10 and June 9 and grown under shade produced a significantly ($p<0.05$) higher mean number of leaves than those planted under open growth environment. Planting on May 10 resulted in a significantly ($p<0.05$) higher number of leaves than planting on June 9. Plants planted on May 10 and grown in the greenhouse resulted in a significantly ($p<0.05$) higher number of leaves than those planted on June 9 (Table 5).

Table 4: Main effects of planting date and growth environment on mean number of leaves per seedling plant produced from TPS after transplanting

	Mean number of leaves per seedling plant after transplanting									
	Days after planting									
Treatments	48	62	76	90	104	118	132	146	160	174
Planting date										
May 10	7.85b	10.26b	14.30b	17.11b	26.41	36.26	36.37b	46.22	54.72a	40.23a
May 25	8.85a	11.67b	13.41b	19.63b	27.04	31.31	32.07b	44.70	31.29b	29.72a
June 9	9.74a	13.00a	21.59a	25.48a	33.84	43.21	53.79a	39.67	35.89b	41.89a
LS	*	*	*	*	NS	NS	*	NS	*	*
$LSD_{0.05}$	0.90	1.89	3.86	5.34	4.98	6.54	8.86	10.75	13.17	13.89
Growth environment										
Shade	8.48a	11.04a	15.78a	20.96a	30.70a	38.26a	47.63a	49.68a	65.67a	56.70a
Open field	8.50a	11.00a	14.96a	18.07a	25.04b	34.23a	40.03ab	44.38ab	40.64b	29.07b
Green house	9.41a	12.89a	18.56a	23.19a	31.36a	37.79a	32.17b	35.27b	18.37c	6.56c
LS	NS	NS	NS	NS	NS	NS	*	*	*	*
$LSD_{0.05}$	0.90	1.89	3.86	5.34	4.98	6.54	8.86	10.75	13.17	13.89
PD × G.E	NS	NS	NS	NS	NS	NS	NS	*	*	NS

LS = Level of significance
LSD= Least significant difference

Table 5: Interaction of planting date and growth environment on mean number of leaves per plant at 146 DAP

	Number of leaves per plant					
	Growth environment					
Planting date	146 DAP			160 DAP		
	Shade	Open field	Greenhouse	Shade	Open field	Greenhouse
May 10	46.20b	39.60b	48.57a	65.61a	47.52a	46.00a
May 25	39.77b	34.67b	29.00b	44.36b	40.22ab	9.51b
June 9	73.00a	66.47a	12.50c	71.55a	32.66b	0.71b
$LSD_{0.05}$		11.79			14.31	

LSD= Least significant difference

Planting on May 10 resulted in increase in plant height as the crop age increased up to 160 DAP; thereafter, plant height decreased. For planting on May 25, plant increased with the crop age up to 132 DAP and thereafter decreased. For June 9 planting, plant height increased with the crop age up to 90 DAP, after which it decreased. Generally, planting on June 9 resulted in taller plants than planting on May10 and May 25 (Table 6).

The environment significantly affected the plant height at but 62 DAP. At 48, 76, 90, 104, 118 and 132 DAP, the highest plant height was observed in plants grown in the green house. At the latter stages of growth, the highest plant height was observed in plants grown under the shade. Generally, the lowest plant was observed in plants grown in the open field (Table 6).

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A significant interaction of planting date and growth environment on plant height was observed at 132, 146 and 160 DAP (Table 7). At 132 DAP, the highest plant height of 44. 3 cm was observed in plants planted on June 9 and grown under the shade, followed by those grown in the greenhouse (38.7 cm) and in the open field (19.5 cm). At 146 DAP, plant height was highest when seedlings were planted on May 10 and grown under the shade, in the open field and in the greenhouse. Seedlings planted on May 25 and grown in the open field had similar plant height with those planted on June 9 and grown under the shade or in the open field. The seedlings planted on June 9 and grown in the greenhouse had the lowest plant height of 0.7 cm (Table 7). At 160 DAP, the highest plant height (44.3 cm) was observed when seedlings were planted on June 9 and grown under the shade or in the green house.

Table 6: Main effects of planting date and growth environment on mean plant height at stages of growth and planting

	Plant height (cm)									
	Growth stage (Days after planting)									
Treatment	48	62	76	90	104	118	132	146	160	174
Planting date										
May 10	5.79b	13.33a	13.94b	18.70b	22.14b	25.96a	25.78a	27.30a	28.46a	21.61a
May 25	6.43b	13.13a	18.13b	24.58a	29.43a	23.91a	30.69a	17.93c	17.64b	11.28c
June 9	8.77a	10.70a	22.43a	28.23a	26.53ab	26.00a	27.62a	26.76ab	22.69ab	20.72ab
LS	*	NS	*	*	*	NS	NS	*	*	*
$LSD_{0.05}$	1.47	3.16	3.36	4.19	5.36	6.43	5.41	8.71	9.34	8.73
Growth Environment										
Shade	6.67b	12.28a	17.54b	23.75b	28.37ab	32.83a	25.32bc	38.08a	38.46a	37.73a
Open field	5.69bc	13.54a	12.75c	15.06c	16.18c	16.04c	26.83b	16.19b	14.88c	11.92b
GH	8.62a	11.34a	24.41a	32.70a	33.54a	26.99ab	34.09a	15.47bc	15.47b	3.96c
LS	*	NS	*	*	*	*	NS	*	*	*
$LSD_{0.05}$	1.47	3.16	3.36	4.19	5.36	6.43	5.41	8.71	9.34	8.73
PD×GE	NS	NS	NS	NS	NS	NS	NS	*	*	*

GH = Green house
LS = Level of Significance
LSD = Least Significance Difference

Table 7: Interaction of planting date and growth environments on mean plant height at 132, 146 and 160 DAP

	Plant height (cm)								
	Growth Environment								
	132 DAP			146 DAP			160 DAP		
Planting date	Shade	Open	GH	Shade	Open	GH	Shade	Open	GH
May 10	33.94b	17.68a	22.34c	43.47a	17.39a	30.31a	33.94b	17.68b	22.34c
May 25	28.16c	12.44b	34.78b	25.86b	18.67a	19.35b	28.16c	12.44b	34.78b
June 9	44.33a	19.52a	38.67a	42.22a	17.48a	0.71c	44.33a	19.52b	38.67a
$LSD_{0.05}$		3.32			8.66			3.32	

GH =Green-house
LSD=Least Significance Difference

Number of Tubers per Plant and Mean Tuber Weight

Table 8 shows the mean number of tubers per plant and mean tuber weight. The mean number of tubers per plant significantly ($p< 0.05$) differed with planting date. Planting on May10 and June 9 resulted in a significantly higher number of tubers per plant than planting on May 25.

The mean tuber weight was significantly higher (18.9 g) in tubers harvested from June 9 plants (18.9) than in those planted on May 10 (12. 1 g) or May 25 (10.7 g). Tubers harvested from plants grown under the shade (17.5 g) and in the open field (15.6 g) were significantly heavier than those grown in the greenhouse (8.7 g).

Table 8: Main effects of planting date and growth environment on mean number of tubers per plant and mean weight of tubers

Treatment	Mean Number of tubers/plant	Mean Weight of Tubers (g)
May 10		
May 25	13.15a	12.14b
June 9	7.78b	10.70b
May 10	11.19a	18.94a
LS	*	*
$LSD_{0.05}$	4.34	5.76
Growth Environment		
Shade	14.00a	17.49a
Open	12.11a	15.62a
Greenhouse	5.74 b	8.67b
LS	*	*
$LSD_{0.05}$	4.34	5.76

Tuber shape

Table 9 shows the different shapes of tubers produced from the true potato seed. Obovoid-shaped tubers were the highest in number (217), followed by long-oblong tubers (186), compressed (122), round (92), oblong (82), elongated (56) and the elliptic shape tubers (1) (Table 9).

Table 9: Shapes of tuber produced from true potato seed

Planting date	Total Number of Progeny	Compressed	Oblong	Round	Obovoid	Long-Oblong	Elongated	Elliptic
May 10	281	63	40	18	55	85	20	
May 25	202	59	24	4	61	32	21	1
June 9	273	-	18	70	101	69	15	-
Mean	756	122	82	92	217	186	56	1

Table 10: Meteorological data for the period of study

Months	Weeks	Minimum Temperature(°C)	Maximum Temperature(°C)	Humidity (%)	Rainfall (Mm)
May	1(7th may)	23	28	66	56
	2(14th may)	23	28	67	64
	3(23th may)	23	28	70	87
	4(31st may)	22	28	62	53
June	1(8th June)	21	27	70	25
	2(15th June)	20	29	66	44
	3(22nd June)	21	29	71	20
	4(28th June)	20	25	64	24
July	1(7th July)	15	28	72	39
	2(15th July)	15	29	78	27
	3(21st July)	15	26	77	21
	4(30th July)	14	29	77	28
August	1(8th August)	16	29	78	18
	2(15th August)	14	29	82	37
	3(22nd August)	14	29	77	35
	4(31st August)	15	29	79	37
September	1(7th September)	15-	29	72	13
	2(14thSeptember)	13	30	67	13
	3(21st September)	14	29	67	17
	4(30th September)	14	29	69	7.4
October	1(7th October)	14	28	53	15
	2(15th October)	17	28	48	6.2
	3(23rd October)	20	26	46	13
	4(31st October)	19	30	42	2.8

Source: Meteorological station, Federal College of Forestry, Jos, Nigeria

DISCUSSION

The effects of planting dates on germination and establishment of true potato seed showed that TPS planted on May 10 recorded a significantly higher germination and establishment of TPS seedlings, while TPS planted on June 9, recorded the least germination and establishment of seedlings from TPS. This suggests that early planting enhances germination and establishment of TPS. This may be due to conducive environment necessary for germination at the time of sowing such as warmth, soil moisture and relative humidity. Maximum temperature during the trial ranged from 28-29°C while minimum temperature during ranged from 21-23°C (Table 10). Jamro *et al.* (2015) observed that germination percentage increased due to favourable temperature of 19.3 to 35.8°C and optimum moisture at the time of sowing. Increase in germination percentage can enhance the establishment rate, plant population and productivity. Dhakal *et al.* (2003) reported temperature as the basic requirement for germination.

Plant height and number of leaves per plant at transplanting varied significantly with planting date. The TPS planted on June 9 recorded the highest plant height and number of leaves at transplanting. This could be due to favourable temperature, air moisture and rain establishment at the time of transplanting. Okonkwo *et al.* (1995) suggested that transplanting should be done when rain has stabilised, usually in the first or second week of June in Jos-Plateau. Planting of TPS can also be done directly in the field. Okonkwo *et al.* (2009) recommended that seedlings should be raised in the nursery in seed beds, seed trays or pots before transplanting.

The effect of planting date on the mean number of leaves per plant after transplanting showed that TPS seedlings planted on different dates showed linear increase in the mean number of leaves as the cropping season progressed. The TPS planted on June 9, 2019 resulted in a higher number of leaves from 48 to 132 DAP. There was a decline in the number of leaves at 160 DAP for TPS planted on May 25 and at 146 DAP for TPS planted on the June 9. The decline in the number of leaves could be due to leaf senescence. Archana *et al*. (2017) observed that the leaf area index increased in the early stages of growth and thereafter declined slowly up to harvest under subtropical condition.

The effect of growth environment on the mean number of leaves was not significant throughout the sampling periods except at 146 and 160 days after planting. Growing the plants under greenhouse resulted in a higher number of leaves than in the open environment. Plants grown under reduced light display an excessive elongation with long internodes. This may explain why plants in shade environment recorded the highest number of leaves throughout the sampling periods. The use of shading net has been reported to increase the leaf surface area index (Al-Mahmud *et al*., 2015).

The planting date had a significant effect on plant height after transplanting. Variation in plant height could also be due to genotype, since the TPS seeds were open-pollinated. Jamro *et al.* (2015) reported maximum plant height when TPS genotype 9804 was planted on October 30, 2009. The effect of growth environment on mean plant height was significant throughout the sampling periods, except at 62 and 132 DAP. The differences observed in mean plant height due to growth environment may have resulted from the variation in solar radiation in the different growth environments. Greenhouse and shade environments recorded a significantly higher plant height than the open field. Light is essential for photosynthesis, without which weak seedlings of poor quality are produced. These seedlings display an excessive elongation referred to as etiolation. Gawronska *et al.* (1990) observed that potatoes grown under low irradiance were taller but the tubers were smaller and irregular in shape.

Planting date had a significant effect on the number of tubers per plant. Planting on May 10 and June 9 resulted in a higher number of tubers than planting on May 25. Planting on these dates resulted in taller plants with more leaves and increased photosynthetic activity and high tuber yield. Higher tuber yields have been attributed to increased photosynthesis and biomass of the plants (Menzel, 1985).

The growth environments significantly affected the mean number of tubers per plant. Planting under shade and open environments resulted in the highest mean number of tubers, while greenhouse recorded the least. This may be due to variation in temperature and sunlight. Menzel (1985) reported good tuberisation of potato under continuous light. The mean weight of tubers produced from TPS seedling varied significantly with planting date. Planting on May10 and June 9 resulted in a significantly higher weight of tubers than planting on May 25. The high mean weight of tubers observed could be due to favourable temperature, which enchanced proper stolon development and tuber initiation (Kooman *et al.*, 1996b). The environment also affected the mean tuber weight significantly. Growing plants under shade and in the open environment resulted in tubers with higher weight than in the greenhouse. This may be due to direct exposure to sunlight which enhanced photosynthetic activity.

Tubers of varying shapes were observed in this study, ranging from compressed to elliptic shape. It has been observed that potato tubers produced from TPS do not have uniform skin colour and tuber shape (Okonkwo *et al*., 1998).

CONCLUSION

Results obtained from this study have shown that early planting (May 10) resulted in higher germination percentage, mean number of leaves per plant, plant height, number of tubers per plants and mean weight of tubers compared to mid-planting (May 25). It can be concluded that early planting enhances seed tuber production from TPS.

Shaded and open field produced significantly higher mean number of tubers per plant and mean weight of tubers than the greenhouse environment. It can also be concluded that shade and open field enhanced seed tuber production from TPS in Jos Plateau, Nigeria.

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